Metropolitan Transportation Management Center Concepts of Operation

A Cross-Cutting Study

Improving Transportation Network Efficiency

October 1999

Foreword

Dear Reader,

We have scanned the country and brought together the collective wisdom and expertise of transportation professionals implementing Intelligent Transportation Systems (ITS) projects across the United States. This information will prove helpful as you set out to plan, design, and deploy ITS in your communities.

This document is one in a series of products designed to help you provide ITS solutions that meet your local and regional transportation needs. We have developed a variety of formats to communicate with people at various levels within your organization and among your community stakeholders:

- **Benefits Brochures** let experienced community leaders explain in their own words how specific ITS technologies have benefited their areas;
- **Cross-Cutting Studies** examine various ITS approaches that can be taken to meet your community's goals;
- **Case Studies** provide in-depth coverage of specific approaches taken in real-life communities across the United States; and
- **Implementation Guides** serve as "how to" manuals to assist your project staff in the technical details of implementing ITS.

ITS has matured to the point that you don't have to go it alone. We have gained experience and are committed to providing our state and local partners with the knowledge they need to lead their communities into the next century.

The inside back cover contains details on the documents in this series, as well as sources to obtain additional information. We hope you find these documents useful tools for making important transportation infrastructure decisions.

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Background

The implementor and operator of a regional transportation management center (TMC) face a challenging task. Operators of TMCs—the primary point of coordination for managing transportation resources—typically control millions of dollars of intelligent transportation system (ITS) equipment implemented regionwide. Yet relatively sparse material has been published regarding TMC implementation and operation. Thus, to support the TMC's implementation and operation, the implementor and operator have had to depend on personal experience, the knowledge and expertise of other individuals within their agency, a personal network within the transportation trade, and the firm or firms hired to assist the agency implementing the TMC.

If the implementing agency has little or no experience using technology-intensive systems to manage transportation, the concept of how the TMC's systems are to be used may not be well formed, and it will be difficult to communicate this vision clearly to the design team and to the implementor. The unfortunate result may be a system that the operations staff members find difficult to manage and that is both less effective and shorter lived than is desired.

Developing and documenting a concept of operations forces the implementing agency to explicitly address and understand operational issues, such as staffing, education, and training; information and control sharing; and the decision-making hierarchy. It also assists in more clearly defining the system configuration and information content, user interface, and other system parameters for the system designer and developer.

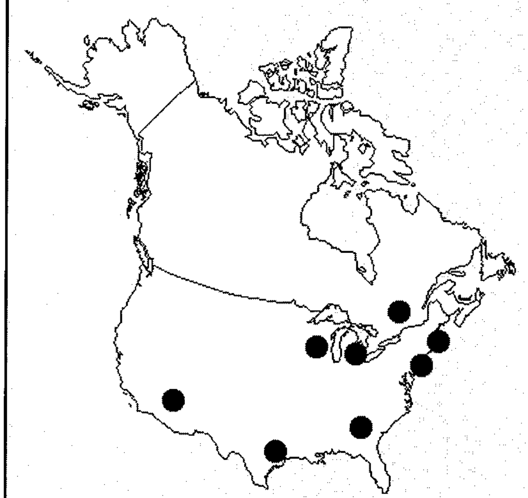
This document provides information on operations at various TMCs within the United States and Canada. While a primary focus of each of these centers is freeway management, several are also responsible for traffic signal system operation and various aspects of transit system management. The majority of the study addresses the centers' freeway management activity. The study team, in its in-depth review of these centers, began with a review of existing published TMC operations material and a current listing of major U.S. freeway management centers. The following eight centers were chosen for detailed investigation and documentation, representing a broad range in their systems' size, age, purpose, and technical approach:

- Detroit, Michigan, Intelligent Transportation Systems Center
- Milwaukee, Wisconsin, MONITOR
- Long Island, New York, INFORM
- Boston, Massachusetts, Integrated Project Control System
- Houston, Texas, TranStar
- Phoenix, Arizona, TrailMaster
- Atlanta, Georgia, NaviGAtor
- Toronto, Ontario, COMPASS.

Background

Based on the operations concept defined in the article, "The ITS Operations Concept: A Missing Link in System Definition," in the Winter 1997/Spring 1998 edition of *ITS Quarterly*, a three-page survey was prepared as a data gathering tool. The study team visited each of the eight TMCs for 1 to 2 days, interviewed TMC personnel at all levels of operations and maintenance responsibility, and observed system operation for several hours, typically including a complete multihour peak period.

The situation and mission of each TMC vary, so different lessons and experiences—documented in this study—were gained from each TMC visited. The study team gathered "best practices" and "lessons learned" in the operation of those TMCs. The team also identified major issues that were challenging most existing centers, such as staffing and the relationship between operations and maintenance functions. The team asked study participants to provide their perspectives on future directions for TMCs and TMC support systems. Interviews at each of the TMCs typically resulted in 10 to 15 pages of typed notes.


Location of TMCs included in this study

The data the study team gathered throughout its efforts are consolidated in this document. As such, this document provides potential TMC implementors and existing TMCs that desire to improve their own operations with real-world examples of how their peers are addressing daily operational issues.

The study team discovered that a majority of TMCs lacked a documented concept of operations. A thorough understanding of the operations approach is essential when acquiring systems and developing procedures. A concept of operations can be a valuable tool in achieving and sharing this understanding.

Some of the lessons learned and described in this document (e.g., underestimation of operator workload, transition from video monitor walls) are indicative of human factors issues which are concerned with the design of TMC system elements. Additional good human factors practices related to equipment, operator tasks, and procedures are documented in the report, *Comparable Systems Analysis: Design and Operation of Advanced Control Centers* (August 1995). Also, *Preliminary Human Factors Guidelines for Traffic Management Centers* will provide guidance on human factors design issues for TMCs (September 1999).

Background

Basic Outline of a TMC Concept of Operation

The data the study team gathered have been condensed into sections on Best Practices, Lessons Learned, Issues, and Future Directions. The Best Practices and Lessons Learned sections follow the basic outline for a TMC concept of operations as shown below. Lessons Learned were gathered on a nonattribution basis, and staff at each TMC were willing to contribute generously of their hard-earned experiences.

Throughout the remainder of this document each TMC will be referred to by the name of the city in which it is located, although several of the TMCs manage either regional or statewide road networks.

The basic outline of a TMC concept of operations used for this study is as follows:

- Background
  - The need, purpose, and concept for the system
  - The mission, vision, goals, and objectives that relate to the services the system delivers
- System design and implementation
  - General system design parameters
  - Devices in the system and their interoperation
  - Method of system implementation
  - System testing
  - Operations readiness testing
  - System training and documentation
- System operation
  - Workload and performance
  - Coordination
  - Conflict resolution
  - Nonstandard operations
  - Fault detection and correction
- System maintenance
  - Configuration management
  - Logistics
  - Maintenance
  - Operations simulation.

Background

This outlined concept of operations provides more background information, particularly in the area of procurement, than would be the case with a concept of operations for a new system or for a more scientific application—such as a National Aeronautics and Space Administration [NASA] control center—because this information was considered useful to agencies implementing TMCs. Some subsection topics, such as systems testing, are applicable multiple times during the life cycle of a TMC, both at its beginning and any time it undergoes a significant change or upgrade. Other subsections, such as nonstandard operations, reflect multiple conditions (e.g., special events and emergency operations) combined into a single section.

TMC Summary Descriptions

Boston Central Artery/Tunnel Integrated Project Control System

The **Integrated Project Control System** is an integrated traffic management and tunnel systems control application for Boston's 7.5 mile Central Artery/Tunnel system. It is one of the most complex and reliable systems of its type, featuring an extremely high density of field equipment, and double or triple redundancy in many elements. The objective of this system is to monitor security, traffic, and systems (fire, water level, air quality) status, and to respond to incidents, nonstandard needs, or failures rapidly and effectively. The traffic management components also support management of traffic through the heart of Boston and to and from Logan Airport, and thus they are also involved in supporting both daily travel and any special events that occur on Boston's roadways. The Integrated Project Control System applies vehicle detectors, overheight detectors, closed-circuit television, lane control signals, and variable message signs communicating over a fiber optic network. The system is being implemented by the Massachusetts Highway Department, and is operated by the Massachusetts Turnpike Authority.

Toronto, Ontario COMPASS Downsview TMC

The **COMPASS Downsview TMC**, built and operated by the Ministry of Transport, Ontario, balances traffic between express and collector lanes on Highway 401, and provides incident detection and incident management. COMPASS uses vehicle detectors, closed-circuit television, and variable message signs communicating over a fiber optic network. A 1994 evaluation showed that the COMPASS system has resulted in a reduction in average duration of incidents from 86 minutes to 30 minutes, that the system prevents about 200 accidents per year, and that average speed has increased 7 to 19 percent. Two smaller COMPASS TMCs in the Toronto area monitor adjacent roadways.

Long Island, New York INFORM

The **INFORM** system on Long Island uses vehicle detectors, closed-circuit television, traffic signals, ramp metering, and variable message signs communicating over a coaxial network to identify traffic congestion and incidents or situations likely to cause congestion, and to provide information to motorists and incident management resources to minimize the duration and impact of such situations. The system monitors and manages traffic on Long Island's three major east-west limited access routes, with work under way to instrument north-south arterial connector routes as well. The INFORM TMC also hosts the regional motorist assistance patrol. INFORM was implemented by the New York State Department of Transportation, and is operated under contract. Results of INFORM studies show that freeway speeds increased 13 percent despite an increase of 5 percent vehicle miles traveled for the afternoon peak. The number of locations with speeds of less than 30 mph decreased by 50 percent for the morning peak. A study of INFORM ramp metering found a 15 percent accident reduction and a 9 percent increase in speed.

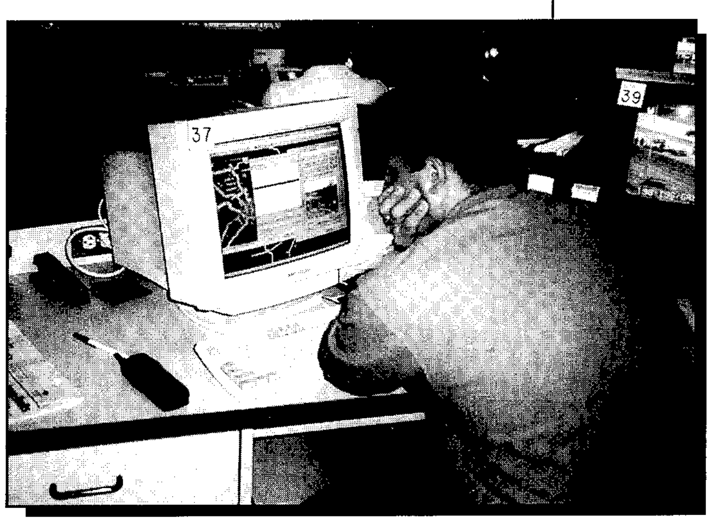
TMC Summary Descriptions

Detroit, Michigan Intelligent Transportation System Center

The **Michigan Intelligent Transportation System Center** contains both an original system dating from 1981 covering 32.5 miles, and an expansion of the system to cover a total of 180 centerline miles of freeway that is still under way. The former system includes ramp meters, detectors, and closed-circuit television with communications via coaxial cable. The latter system includes the same components and highway advisory radio, communicating via microwave and spread spectrum radio to an OC-48 fiber optic network. The focus of the TMC is to make the traveler's trip less stressful by providing better information so the traveler can avoid congestion or other driving problems. The system is being implemented by the Michigan DOT, and is in the process of privatizing operation. The TMC is jointly staffed with Michigan State Patrol. A study of ramp meters in Detroit measured a 50 percent accident reduction, an 8 percent increase in speed and a 12.5 percent increase in demand. The current expansion of the freeway management system is expected to reduce delays from incidents by about 40 percent. This would lead to an annual reduction of 41.3 million gallons of fuel used, a reduction of 122,000 tons of carbon monoxide, 1,400 tons of hydrocarbon and 1,200 tons of nitrogen oxides.

Milwaukee, Wisconsin MONITOR

MONITOR is the Wisconsin DOT's freeway traffic management system for metro Milwaukee. MONITOR was implemented to address congestion problems on and incident vulnerability of the region's incomplete freeway system. MONITOR uses vehicle detectors, closed-circuit television, traffic responsive ramp metering with high occupancy vehicle (HOV) priority, freeway and arterial variable message signs, and highway advisory radio. A full-time liaison from the county Sheriff's department in the TMC provides coordination with law enforcement. The TMC is also the focus for regional distribution of road closure information. Wisconsin DOT has reported a 14.8 percent reduction in crashes and travel time reductions of 9, 12, and 16 percent on three separate roadway segments as a result of MONITOR's systems. AM peak period average speed has increased 3 percent while volume has increased 22 percent. Net savings of 1,454 driver hours per peak hour have been calculated as a result of ramp metering alone.



TMC Summary Descriptions

Atlanta, Georgia NaviGAtor

Atlanta's **NaviGAtor** was originally conceived to address transportation needs for incident management, congestion management, and motorist assistance during the 1996 Olympic Games in Atlanta. It accomplishes these goals by providing to motorists accurate and timely information for navigating the roads of Georgia. NaviGAtor's mission has been expanded to serve as part of the Georgia DOT's statewide freeway incident management program. It uses vehicle detectors, closed-circuit television, variable message signs, and ramp meters communicating over a fiber optic and microwave network. The NaviGAtor TMC also hosts the area motorist assistance patrol program and the state's commercial vehicle operations enforcement program. The delay between the report of a crash and dispatch of emergency services has been cut in half, and accidents are cleared from the roadway 38 percent faster.

Phoenix, Arizona TrailMaster

The **TrailMaster TMC** in Phoenix is the hub of the Arizona Department of Transportation's statewide freeway incident management program. The objectives of TrailMaster are to support optimum utilization of the freeway system, provide a safe and efficient environment for users, and ensure efficient utilization of ADOT resources. The system uses vehicle detectors, closed-circuit television, and variable message signs communicating to the control center over a fiber optic network. Traveler information is provided via multiple methods, including on-site broadcaster, Web site, video feeds to other media, and the AZTech metropolitan model deployment initiative kiosks, onboard navigation, computerized telephone, and bulletin board systems. The TMC also hosts the state's highway closure reporting system. In a study of a typical incident, Arizona DOT found that the rapid incident detection and response from TrailMaster resulted in diversion of 21 percent of the vehicles traveling on the affected roadway, resulting in a savings of 1,452 vehicle hours for this incident.

Houston, Texas TranStar

Houston TranStar is a multiagency transportation management center providing traffic management, traveler information, and emergency management for the greater Houston area, including limited assets in Galveston. Agencies involved include the Texas DOT, the City of Houston, Harris County, and Houston Metro. Houston and Harris County Offices of Emergency Management are also present. The goals of Houston TranStar are to manage emergency response, promote emergency management awareness and public safety, promote the benefits of Houston TranStar, increase efficiency, improve productivity, and enhance mobility, congestion management, and safety. TranStar resources include variable message signs, highway advisory radio, loop detectors, closed-circuit television, lane control signals, ramp meters, a motorist assistance patrol, and an AVI-based congestion detection system extending beyond the conventionally detectorized area. An extensive (3,000 intersection) traffic signal system upgrade/replacement is also under way. A conservative estimate of average freeway incident time savings as a result of the TranStar system is 5 minutes, but analysis has shown that a savings of 30 minutes is possible for major freeway incidents. Total annual delay savings is estimated at 573,095 vehicle-hours, resulting in about $8.4 million in savings per year.

Successful Practices

Planning

None of the eight TMCs visited had developed a concept of operations before the TMC was implemented, although most had conducted planning before implementing their systems. Interviewees from TMCs that conducted thorough planning confirmed that the sense of direction gained by documenting the TMC's understood mission, vision, goals, and objectives made center operations much easier. Houston, having recently undergone its first leadership transition, was actively revisiting its strategy to focus its efforts and redefine priorities and methods. Toronto was also revisiting its defined and documented system objectives given current changes in agency and program direction.

Phoenix's strategic view was long term, including all 17 phases of ITS deployment in the metro Phoenix region, and its transition to a statewide center. Much of the early planning in Phoenix, as at several other TMCs, had been established in its feasibility study and functional design documents.

Planning provided a strong sense of direction for all TMCs, but was more effective when backed up by ongoing performance analysis and process improvement. Both Toronto and Atlanta performed benefits analysis studies. In addition, Atlanta had a vigorous program of monitoring and evaluating responsiveness to traveler calls. Several of the eight TMCs evaluated their performance after large or unusual incidents, seeking ways to improve. Most of the newer systems provided fully automated logging of data, status, and actions, making such analysis possible. Phoenix performs ongoing analysis of advanced traffic management system collected data, examines operations performance, and identifies areas for improving the region's overall traffic conditions.

System Design and Implementation

General

Most TMCs have found that, once they are operational, public and agency expectations for their assistance build rapidly. One effect of this demand is that most TMCs implement computer systems that have significant redundancy so that they remain operational even if the primary computer fails. Boston, whose computer provides life-critical (pumping, ventilation, fire control) as well as traffic management functions, has implemented a triple-redundant computer system. Although this level of redundancy is unnecessary at most TMCs, other TMCs such as Houston and Atlanta have seen value in implementing computer systems with increased reliability. Two approaches followed have included "high-availability" processing with a hot backup system, where loss of a single processor does not disable the entire system, and distributed processing where functions from a malfunctioning processor can be redistributed to other processors within the system.

As discussed earlier, the primary purpose of developing a concept of operations is so that the system will match the users' operational needs. An additional tool used in Houston to ensure this match was to create a simulator during system development. As Houston's system was developed, the simulator allowed Houston's operations personnel to verify that the system's "look and feel" matched their concept of how transportation would be managed at their TMC. Houston's developer was able to test concepts within the system design at a relatively low cost—before significant investment was made in fully coding system functions and building an elaborate user interface. Phoenix required its system developer to provide the computer-aided software engineering tools that had been used in developing its system and to support long-term system documentation and improvement.

A complementary development technique is to create a database of traffic data for testing new or revised system functions or releases, as Houston, Milwaukee, and Phoenix did.

Training and Documentation

When TMC operations staff members are hired, bringing them up to speed and keeping them informed of proper procedures is critical for ensuring successful operations. Several of the TMCs had developed and refined their operations procedures. The study team reviewed those from Boston, Toronto, and Atlanta in detail as examples. Innovative training and documentation procedures observed include Boston's plans for online procedures, Toronto's "functionally" oriented help function, and Atlanta's use of hypertext in help and training materials.

Successful Practices

Boston—due to the constantly changing condition of its road network because of the construction of the Central Artery/Tunnel—has a program of continually updating its procedures. Toronto has reorganized its operations department to include an individual assigned to maintain and update its procedures, and Atlanta has created a training and documentation staff within its operations department. Atlanta has also created a position in its ITS organization for document control.

Because of the frequent change of its procedures, Boston has implemented desktop rehearsal and new and altered procedure simulations to ensure operational readiness. Atlanta periodically assigns its operators to accompany the services they support and interact with, such as the motorist assistance patrol.

Atlanta's training program offers examples of several valuable practices. Atlanta has established a training unit in its planning department, which prepares operations procedures. New operators begin with a 2-week formal training program on the operator console and software and progress to 3 to 4 days each of training on various duties, procedures, and response plans. New hires are provided tours of the project area to gain familiarity with the road network and device locations. They also ride with the motorist assistance patrol during their new hire training.

Milwaukee recognized the need for a different orientation in the training of its law enforcement partner and has developed a customized training manual for its use. Milwaukee has provided a system workstation at the law enforcement dispatch site and has received positive feedback from the law enforcement dispatchers regarding this access.

Sample Control Center Documentation

Toronto	Atlanta
Standard Operating Procedures	Standard Operating Procedures
Patrol List	Incident Management Handbook
Tech and Electrical Binder	MOVER Manual
Nuclear Emergency/ Provincial Emergency Manual	Equipment Manual
Schematic Drawings	Location Guide
Emergency Telephone Numbers	ATMS User Guide
Construction Contract Listings	Signals Listing
Driver and Vehicle System Binder	TMC Equipment Guide
Service Crew Binder	Operations Supervisor Guide
Burlington Emergency Contacts	Information Directory (Points of Contact)
QEW Schematic Drawings	

Incident/Congestion Detection Methods

Boston	Toronto	Long Island	Detroit	Milwaukee	Atlanta	Phoenix	Houston
Loops	Loops	Loops	Loops	Loops	Loops	Loops	Loops
CCTV	CCTV	CCTV	CCTV	Radar	Radar	PAD	CCTV
MAP	Police	MAP	Police	CCTV	VIDS	CCTV	Police
Scanner	Motorist Calls		MAP	Police	CCTV	MAP	Buses
					MAP	Police	MAP
					*DOT Calls		Probes
					Other Agencies		
					Police		

CCTV—Closed-Circuit Television
MAP—Motorist Assistance Patrol
PAD—Passive Acoustic Detector
VIDS—Video Imaging Detectioon System

Successful Practices

System Operations

General

The study team noted many excellent practices in the regular operation of TMCs. Both Detroit and Milwaukee were able to streamline their incident detection by leveraging the information from cellular 911 calls received by law enforcement agencies that were located in their control rooms. To monitor roadways under construction and gain an effective picture of the subsequent traffic disruption, Milwaukee used relocatable detection equipment. Houston exploited its existing toll tag population, using vehicles as probes and extending its detection network far beyond the instrumented area.

Several TMCs have begun implementing travel time or congestion-level messages as defaults on their variable message signs during peak periods. Toronto, whose initial goal was flow balancing, pioneered the use of congestion-level messages. Atlanta and Milwaukee now display travel times or time ranges on their variable message signs. Although there are multiple methods for travel time calculation and varying opinions on their accuracy, no TMC that posts travel times had received negative feedback regarding the posted times or criticism for investing in expensive but unused assets.

As with the volumes of valuable traffic data that TMC systems generate, TMCs are also realizing the value of videotaping traffic patterns for traffic studies.

Phoenix and Toronto have supplemented the typical traffic information available to their TMC operators with information from their road weather information systems (RWIS) devices. Typically, this information is available via a separate terminal, but it can be very useful in developing the optimal traveler information strategy.

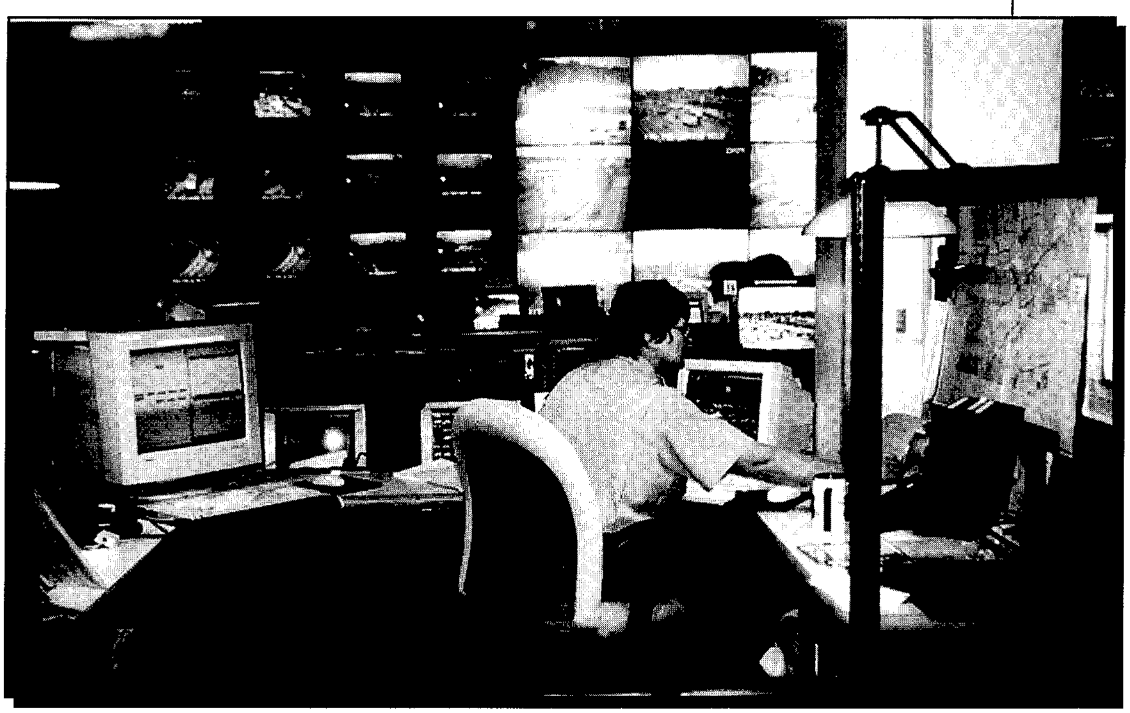
The study team noted several innovative shift change procedures, such as Milwaukee's "shift transfer function" within its advanced traffic management system, which transfers full history and control of all open incidents assigned to a departing operator to his or her replacement for the next shift. Most TMCs organized their operations shifts to overlap 15 to 30 minutes, with possibly greater overlap for shift leads and supervisors. In Boston, "pass down," "shift change," and "close out" logs provided incoming TMC operators with a clear picture of what activity had occurred, what was under way, and what had changed in the system. To support operations both during and across shifts, several TMC systems had operator "reminder" functions, ensuring that variable message sign messages did not remain in place longer than was needed.

Staffing

One of the most difficult components of TMC operations and maintenance is staffing. Detroit, having lost approval for its full-time operations positions, has revised its operations to run with temporary personnel. Detroit operations are being privatized. Supplementing its two full-time operators, Milwaukee employs college students in operations. Milwaukee is also contracting for maintenance support. Long Island has a history of successful operations contracting and is considering how this support can be extended to an integrated operations and maintenance contract.

TMC Staffing

	Boston	Toronto	Long Island	Detroit	Milwaukee	Atlanta	Phoenix	Houston
Centerline Miles	7.5	60	165	180	63	220	254	122
Number of Operator Positions	10	9	5	6	3	12	6	18
Number of Prime Shift Operators	3+	3+	5	4	2+	5	2	12
Total Operations Staff	10	12	12	9	5	18	8	19
Number of Operation Staff Levels	3	3	2	2	1	1	2	1
Operations Staff Source	MassPike as Contractor	Agency Staff (FT and PT)	Contractor Personnel	Temporary Part-time	Staff, Students	Staff, Students	Agency Staff	Agency Staff
Number of Shifts	3	3	3	2	2	3	3	3
Backup Operations Staff Resources	Supervision, Off-shift, Overtime	Supervision, Off-shift	Contractor Responsibility	Supervision, Off-shift	Supervision, Professional Staff, Off-shift, Students	Supervision, Professional Staff, Off-shift, Students	Supervision, Off-shift	Varies by Agency



Successful Practices

Hiring Sources for TMC Operations Personnel

Community Colleges
Postings within Agency
Agency Surplus Personnel

Common Backgrounds for TMC Operations Personnel

Traffic Equipment Maintenance
Air Traffic Controllers
Radio Operators
Clerical/Administrative Personnel
Students
Dispatchers

The Massachusetts Highway Department has contracted Boston's operations and maintenance to another agency, the Massachusetts Turnpike Authority. Toronto has contracted for overall preventive maintenance and total maintenance of its variable message signs and its fiber optic communications network. Atlanta has contracted for its variable message signs preventive maintenance program.

Hiring and retaining operations and maintenance personnel is yet another challenge. Long Island, leveraging its location near three major airports, has had success hiring former air traffic controllers as its operators. In Toronto, several radio operators, either from within the agency or from outside, have served as operations staff. Toronto has also had great success hiring graduates from a local 2-year academic institution that features traffic courses. Both Toronto and Atlanta have developed meaningful operator career paths. For example, two Toronto operators have progressed into operations management. Atlanta bases operator pay increases on measured workload and performance.

TMC Participants

	Boston	Toronto	Long Island	Detroit	Milwaukee	Atlanta	Phoenix	Houston
Functions in Control Room	Traffic Operations, Tunnel Control	Traffic Operations, Vehicle Information	Traffic Operations, MAP, Traveler Information	Traffic Operations, MAP	Traffic Operations	Traffic Operations, MAP, Traveler Information, Broadcast	Traffic Operations, Incident Teams, Broadcast	Traffic Operations, Transit Dispatch, Law Enforcement, MAP, Broadcast
Other Functions in TMC	Various (Major Office Building)	Planning, Design, Training, Maintenance, Various (Agency Office Building)	N/A (State Office Building)	Design	Planning, Design, Inspection, Outreach	Planning, Design, Training, Senior Management, HOV & CVO Enforcement, Outreach	Design, Analysis	Projects, Design, Special Events, Emergency Operations, Outreach
Agencies in TMC	MHD, MassPike	MTO	NYSDOT, Contractor	MDOT, Mich. State Patrol	WisDOT	GDOT (Multiple Functions)	ADOT, Arizona State Patrol	TxDOT, Metro Transit, City, County
Approx. TMC Area	5000 sq. ft.	2500 sq. ft.	3000 sq. ft.	14,000 sq. ft.	6500 sq. ft.	73500 sq. ft.	18000 sq. ft.	54000 sq. ft.
Control Room Size	2400 sq. ft.	1800 sq. ft.	625 sq. ft.	3,600 sq. ft.	600 sq. ft.	1300 sq. ft.	2400 sq. ft.	3600 sq. ft.
Number of Operator Positions	10	9	5	6	3	12	6	18

SCADA—System Control and Data Acquisition
CVO—Commercial Vehicle Operations
HOV—High Occupancy Vehicle
MAP—Motorist Assistance Patrol
MHD—Massachusetts Highway Department
MTO—Ministry of Transportation of Ontario

Coordination—Interagency Interaction

Interaction with partner agencies in the incident management process is one of the most important and complex components of TMC operations. The study team observed a wide range of techniques used for this interaction. Both Detroit and Milwaukee had law enforcement officers onsite at their TMCs, with Detroit cohabiting the control room with Michigan State Police dispatchers, and Milwaukee having a dedicated, captain-level liaison on site from the Milwaukee County Sheriff's department. When the captain was attending other duties, a Sheriff's department radio, tuned to the appropriate traffic frequency, remained in operation in Milwaukee's control room. Houston hosts officers from both Houston Metro and Harris County in its control room, and Atlanta has a full-time control room console position for a Georgia Department of Transportation (GDOT) commercial vehicle operation (CVO) and high occupancy vehicle (HOV) enforcement officer. Atlanta noted that it regularly received calls from area law enforcement agencies requesting that it dispatch motorist assistance patrol vehicles to existing incident sites. Extending this relationship to the incident scene, Houston is investigating the feasibility of mobile command centers for incidents and special events, drawing on both military experience and more recent activity in work zone traffic management. Phoenix's ALERT incident site traffic management teams are an important component in scene management.

Because of the numerous agencies involved in transportation in their areas of coverage, Arizona (statewide), Long Island, and Atlanta (also statewide) face the greatest challenges when coordinating with multiple law enforcement units. This coordination is typically conducted via telephone, with either dedicated or "speed-dial" lines to the dispatch functions at the relevant agencies. Long Island also coordinates its efforts with a multitude of agencies because of the significant number of townships on the island.

Houston, given its complex multiagency, multifunction role, recognized the value of having a resource to facilitate its multifaceted activities. The Houston facilitator allows each agency to focus on its skills, resources, and primary purpose in any situation, resulting in faster consensus.

Several of the TMCs the study team visited were focal points for collecting and disseminating information regarding construction-related road closures. Milwaukee has the enviable position of having preapproval authority over all closures on its road network and for being the final authority on initiation of any road or lane closure. The Arizona Highway Closure Reporting System (HCRS) has been so successful that adjacent states have approached the Arizona Department of Transportation (ADOT) about expanding the system for multistate, regional application. Toronto has developed a low-workload system for capturing information about lane closures and faxing that information, regularly updated, to relevant agencies and other interested parties. Atlanta's system—featuring both the central GDOT TMC and traffic control centers (TCC) at the city, counties, and outlying areas in which traffic management is being implemented—shares all such information over the distributed network, allowing partner agencies full access to the closure information in the system.

Interagency coordination is also critical for special event planning. Detroit has implemented procedures to coordinate with its large downtown parking facilities when major events, such as the Society of Automotive Engineers (SAE) annual meeting, which draws 50,000 to 75,000 people to the downtown Cobo Hall occur. Houston monitors parking availability during similar large events. Houston has on-site Houston Metro officers who perform detailed special event planning, and who participate in event execution and coordination. Houston Metro estimated that the Houston TMC manages one special event per week, including some that involve the planned presence of livestock on the roads, and others that may last for several days. Atlanta, supplementing the information it receives from its existing agency relationships, monitors numerous commercial Web sites to ensure it is aware of upcoming activities in the metropolitan area that could affect traffic flow.

Emergency operations are a form of special event that stresses TMC resources. Recently created TMCs had uninterruptible power supplies and diesel generators to ensure their system operations during crises, and several had incorporated shower and locker facilities for personnel assigned to long-term duties. Atlanta had incorporated overnight facilities for personnel in these situations. Houston's emergency operations center is located within the TMC. Houston officials were enthusiastic about the effectiveness of collocating the emergency

TMC Support Facilities

	Boston	Toronto	Long Island	Detroit	Milwaukee	Atlanta	Phoenix	Houston
Uninterruptible Power Supply	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Diesel Generator	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Lockers/Showers	Yes	Yes	No	No	Proposed	Yes	Yes	Yes
Overnight Facilities	No	No	No	No	No	Yes	No	No
Garage	Yes	No	Yes	No	No	Yes	No	No
Dock	No	Yes	Yes	No	No	Yes	No	Yes
Lab/Testbed	Yes	Nearby	No	Nearby	Proposed	Nearby	Yes	Yes
Maintenance Shop	Yes	Nearby	No	Nearby	Nearby	Yes	Yes	Nearby
Fitness Center	No	Yes	No	No	No	No	No	No

operations center and TMC, citing outstanding cooperation and coordination during emergency operations. Toronto has prepared an area adjoining its TMC control room for emergency operations, and Atlanta's TMC is located adjacent to the Georgia emergency operations center.

Toronto noted the importance of reaching consensus with other regional agencies regarding which variable message signs messaging protocols to follow. With highly interdependent freeway, tollroad, and surface street networks, inconsistent message meanings and message-posting procedures among the three organizations involved could create considerable traveler confusion in an already traffic-challenged environment.

University relationships have benefited almost every TMC. Houston has extensively used the Texas Transportation Institute to fulfill research, design, development, operations, and maintenance roles. Milwaukee draws on its two local universities for operations personnel and for students to work on special projects such as improving documentation. Atlanta has used student support to develop its advanced Help function. Phoenix has benefited from using students to conduct both research and Web development.

Coordination with wrecker services is a regular activity for many TMCs. In many cases, wrecker services are contracted for specified areas, and standard practices are established for interaction. The Houston area is supported by an alliance of wrecker companies, working from a common dispatch center. The alliance is presently discussing relocating its dispatch function to a location within the TMC to further improve coordination.

Coordination—Intra-agency Interaction

Although intra-agency interaction is intuitively easier than interagency interaction, it can often be equally complex. Intra-agency coordination typically involves interaction among planning, design, construction, and inspection operations, and maintenance functions within the Department of Transportation (DOT). Effective intra-agency coordination can significantly improve the efficiency of the TMC and help support the DOT in its overall mission.

Similarly, understanding of the TMC's activity and experiences and access to the information it collects can be invaluable to the planning department in assessing future transportation needs and priorities, to the engineering department in designing similar systems for other parts of the state, to administrative departments in determining needs for institutional (procurement, contracting, human resource) reform, and to the maintenance department in planning its staffing and logistics programs.

Milwaukee and Atlanta have taken a direct approach to their TMC intra-agency coordination. Both collocate their planning, design, inspection, and operations under a single TMC organizational unit. For most TMCs, maintenance is located in a separate facility in the metropolitan area and typically reports to the DOT district office, rather than to the ITS unit. On Long Island and in Milwaukee, the operations and maintenance departments are actively involved in system implementation and acceptance. In Houston, extensive daily interaction occurs—by phone, radio, and e-mail—between operations and maintenance regarding equipment status. Phoenix maintains contact with ADOT maintenance statewide through its radio system (in the control room) and via pagers. Also in Phoenix, operations, maintenance, and systems supervisors maintain a joint list of desired system improvements. In Milwaukee, both operations and management personnel can access the advanced traffic management system remotely via a dial-up connection.

Maintenance Staffing

	Boston	Toronto	Long Island	Detroit	Milwaukee	Atlanta	Phoenix	Houston
Number of Maintenance Staff	N/A	3+	N/A	3	3	*	3+	3+
Organization Responsible for Maintenance	Installation Contractor	Agency, Contractors	Maintenance Contractor	Agency District Office	Agency District Office, Communication Contractor, Maintenance Contractors	Agency, System Manager, PM Contractor	Agency District Office TMC Systems Team	Agency District Office
Special Maintenance Elements	None	None	None	None	Information Technology Specialist	Information Technology Team	Systems Team	None
Number of Centerline Miles	7.5	60	165	180	63	220	254	122
Types of Field Equipment	SCADA, VMS, Loops, CCTV, Gates, Overheight, FO Network, AM/FM Rebroadcast	VMS, Loops, CCTV, FO Network, Ramp Meters, RWIS	VMS, Loops, CCTV, Coax Network, Ramp Meters, Traffic Signals	VMS, Loops, CCTV, Coax & FO & Microwave Network, HAR, Ramp Meters	VMS, Loops, Microwave Detectors, AVC, CCTV, Ramp & Freeway Meters, HAR, RWIS	VMS, Loops, Radar, VIDS, CCTV, FO Network, Ramp Meters	VMS, Loops, PAD, CCTV, FO Network, RWIS	VMS, LCS, Loops, CCTV, Gates, FO Network, Ramp Meters

* TMC maintenance is not clearly separable from other maintenance functions.

AVC—Automated Vehicle Classification
CCTV—Closed Circuit Television
FO—Field Office
HAR—Highway Advisory Radio
LCS—Lane Control Signal
PAD—Passive Acoustic Detector
PM—Preventative Maintenence
RWIS—Road Weather Information System
SCADA—System Control and Data Acquisition
VMS—Variable Message Sign
VIDS—Video Imaging Detection System

Transit integration with TMC operation varies widely, driven by both ability and need. Many transit agencies' fleets operate almost totally on signalized roadways, which were not the focus of the eight TMCs studied for this report. In such situations, the need and financial justification for extensive integration is not great, although travelers may be interested in seeing both traffic and transit information while making their mode choice. In situations where the transit fleet depends upon the roads managed by the TMC, such as for express and circulator routes, the value and extent of integration can be significant. Similarly, in situations where the TMC's detection and surveillance networks are limited, information from AVL and operators on buses serving as traffic probes can significantly expand the traffic network information available to the TMC.

Centralized integration typically features transit personnel in the TMC control room. In such cases, often other transit functions, such as bus dispatch, are also migrated to the TMC. Decentralized integration is also possible, through extensive electronic sharing of voice, data, video, and control capability over communications lines between the TMC and transit control centers.

Coordination—Media Interface

Positive TMC interaction with the media can greatly benefit the TMC's mission. Although TMCs are not necessarily designed for such a public relations role, they often become the focus of outreach to the public, to the media, and to the professional transportation community. Although the study team did not focus on this area, several findings of interest were discovered.

Milwaukee, Houston, and Atlanta have outreach staff on site, facilitating their relationship with the media and expanding their ability to broaden understanding of their advanced traffic management system and purpose by the traveling public and key decision makers. Atlanta has initiated direct public outreach efforts through billboards and bus advertisements and regularly leverages the extremely positive image of its motorist assistance patrol program to build support for the state's ITS activities. Atlanta also features preinstalled media hookups and a dedicated media broadcast area. The Phoenix control room hosts a local broadcaster during peak periods, as does Long Island when the broadcaster is available. Toronto, pressed to reduce its operational costs, requires media to pay a subscription fee to access its video feeds, for which media equipment has been placed on site. In both Atlanta and Milwaukee, the media were required to pay for the acquisition and installation of the equipment the media needed to access their computer and video feeds.

Media Interface Examples

	Toronto	Long Island	Detroit	Milwaukee	Atlanta	Phoenix	Houston
Number of Outreach Personnel in TMC	0	0	0	1+	2	0	1
Media Accommodations in TMC	None	None	Being Privatized	None	Broadcast Booth	Broadcast Position	Broadcast Booth/office
Media Agencies On site	None	Metro	Being Privatized	Metro in Building	Radio	Metro	Metro (Designated ISP)
Information Sharing Methods	Faxes to Media Video Feed Subscriptions	Phone to Media Media Visits 1-800 Roadwork Telephone Info & Video to Cable Weather & Traffic Channel Road Closure Faxes Travel Delay & Accident Info Faxes	Incident Report Faxes Road Closure Faxes	Video Feeds Data Stream Road Closure Faxes Data Feed to GCM CTIC	Website Calls to/from Media Calls to TV Stations Press Releases	Website Video Feeds Traveler Telephone Kiosks Onboard Navigation Bulletin Board System	Website

CTIC—Corridorwide Traveler Information Center
ISP—Information Service Provider
GCM—Gary, Chicago, Milwaukee

System Maintenance

Configuration management is a process of documenting and keeping current key information (manufacturer, model, serial number, software version, date installed, etc.) for all hardware and software. Specific settings for devices and changes to the installation such as software upgrades or modifications are also recorded.

Configuration management of systems was a challenge for almost every TMC. Few TMCs had prepared a configuration management database or had implemented such systems at the TMC's inception, but each cited the need for a configuration management database when operations and maintenance began. Atlanta recently staffed two full-time positions for configuration management and has a 100 percent configuration review of its software under way. Toronto also created and maintains a configuration management database, and Boston has integrated its baseline configuration management database with an automated maintenance management tool. Phoenix—in an innovative way to address the challenge of its changing configurations—recently renewed the multiyear purchase agreement with its preferred variable message signs vendor, providing Phoenix total control over the proliferation of brands and models of variable message signs installed in its system.

Most TMC systems automatically detected and reported some device and communication failures, although communication limitations that decreased the polling rate to field equipment could limit the effectiveness. Typically, device failures were displayed by changes in color of the relevant icons on the system map. Atlanta had implemented a system of alarms based on device failure, but found that alarm overload was a major operator workload challenge. Atlanta also found that camera failures could be identified by its Web-based image capture program. Long Island's system provided a menu function that allowed for a full listing of equipment status.

Preventive maintenance was an equally active area for TMCs, both for those newly created and for those experiencing the challenges of maintaining legacy equipment. Phoenix and Boston have both implemented impressive preventative maintenance programs, while Atlanta has contracted for preventative maintenance of its variable message signs. Phoenix has developed special repair techniques to economically manage ongoing maintenance problems such as damage from gun shot. Phoenix has performed a logistics analysis to determine appropriate spares levels and how spares should be divided between piece parts and complete units. Phoenix has also recently completed a study of the 15-year expected cost of maintenance, providing a basis for planning, budgeting, and staffing. Phoenix is planning a similar analysis on distribution of spares statewide as it becomes responsible for additional field equipment at significant distances from Phoenix. To avoid problems with repairing their legacy equipment, both Toronto and Milwaukee implemented planned system upgrades, while Michigan and Long Island were examining methods to continue support for their legacy equipment.

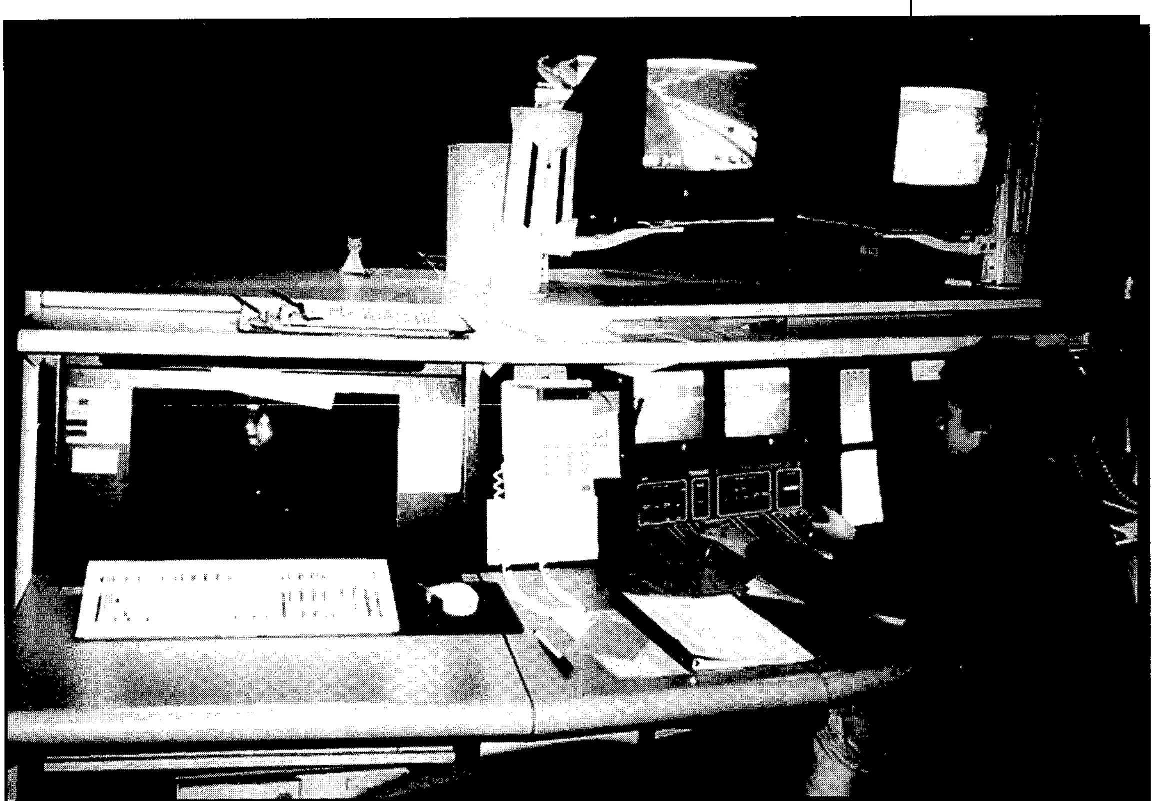
The TMCs the study team investigated were all forthcoming about the challenges they had faced during the planning, implementation, and operations and maintenance of their systems. To most freely express this valuable information, lessons learned are not attributed to specific TMCs or agencies, and neither firms nor products are named.

Planning

TMCs noted several important lessons learned for planning, including—

- Early and strong Metropolitan Planning Organization (MPO) support for the TMC concept in the region helped provide a good foundation for advancing a TMC system and traffic management concepts for many years. Gaining such support also helped define, for those responsible for examining the long-term transportation situation, the regional needs the TMC would meet.
- The TMCs stated that the implementing agency must predetermine (in a feasibility study or conceptual design study) the purpose of the TMC and then ensure that the Advanced Traffic Management System would support that purpose effectively. A system design that did not address and support the specific, known transportation needs of the region (and did not support the involved agencies' long-term transportation strategy) could result in negative public and political reaction and many challenging years of ITS program management.

Background



Lessons Learned

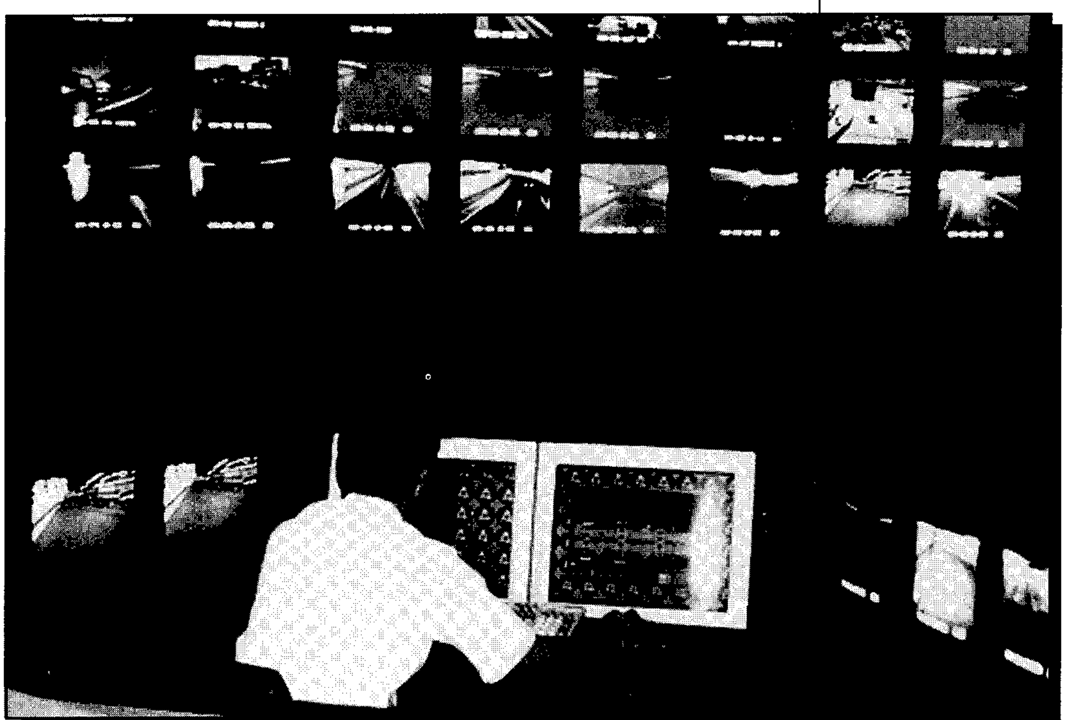
System Design and Implementation

General System Design Parameters—Control Center Design

Regarding design factors that influence long-term control center operations and maintenance, various lessons emerged, including—

- Most control center locations provided easy access to the interstate network for which they were responsible, but two centers were located where downtown street networks hindered quick access to the highway network. These centers noted the value of easy, convenient access for both passenger vehicles and for larger, more unwieldy maintenance and construction vehicles that close proximity to a highway would provide.
- A common theme TMCs expressed was the need for adequate room, including the value of having a facility that could be expanded as space needs increased. Most TMCs soon discovered that when their site was operational, an ongoing stream of agencies and functions found it beneficial to locate within their TMC.
- In multiagency circumstances, one TMC noted the importance of each agency having some "home turf" in the TMC, in which it could comfortably address sensitive internal issues, away from other TMC residents.
- There was general agreement that providing dedicated space to media within the center (typically in or adjoining the control room) supported an effective (and less disruptive) media relationship, and built positively on the TMC's outreach program.
- Levels of security varied widely—from one control center that had adopted a policy of complete and free accessibility (except for the control room) to another where "swipe cards" were needed for every room, stairwell, and elevator.
- Security needs appeared to be driven by the TMC's location (i.e., neighborhood) and by the services provided in the TMC.
- The presence of law enforcement officers in the TMC provided a boost to the security level at those centers with such arrangements.
- A common challenge in control rooms was managing the level of noise, particularly when radios and scanners were being used, including locations where the control center received incoming calls such as cellular 911 or "*DOT." Generally, control centers found that some operators preferred headsets, while others preferred handsets to communicate with outside organizations.
- "Communication by overhearing" also worked effectively at some centers. Only in the largest (or most noisy) control centers were intercoms between console positions needed.

- Those TMCs that hosted both traffic management and emergency management capabilities noted that the TMC needed to be properly configured and outfitted for that mission. Appropriate requirements typically included adequate sizing of backup power units, communications connections, and accommodations for personnel working around the clock.
- Especially for those TMCs where multiple elements of the ITS program (planning, design, construction/inspection, operations, maintenance) were colocated, there was significant value gained by designing laboratory and testing facilities into the TMC. Such facilities supported evaluation of new equipment, testing and calibration of new and repaired units, and debugging of interfaces between the equipment and computer and communications systems.



Lessons Learned

General System Design Parameters—System Design

The TMCs surveyed in this study offered several lessons learned in the design of traffic management systems, including—

- Most TMCs stated they were developing methods for managing workstation "image overload," a condition where the amount of detail on the workstation reached an unproductive level. It was stated that the occurrence of such situations were likely to increase as TMCs became responsible for increasingly large geographic areas. Conveniently controlling the view (most often through a map) of the program area would be essential to effective operation.
- Unstable video cameras created distracting "shaking" images that were insufficient to support incident investigation. Latency in camera actuation was similarly distracting to operators and also negatively affected operational efficiency.
- Widely spaced detector stations were significantly less effective for incident detection.
- The inability to view variable message signs (to verify message status) from cameras was an impediment to both operations and maintenance.
- Both effective video camera placement to provide useful coverage of the road network and adequate magnification were required to gain a sufficient return on the video system investment.
- An adequate networkwide communication capacity was necessary to maintain regular contact with field devices.
- Placing cameras on both arterials and freeways was valuable, even if the agency was responsible only for managing traffic on freeways.
- There was a loss of effectiveness noted from the incomplete integration of management of freeways and surface streets, and from the management of an incomplete highway network.
- Video images displayed on video monitors, rather than shown on a computer screen, was preferred. Using two computer monitors for each computer workstation rather than one per operator was also favored.
- Large systems in particular were transitioning from video monitor walls with dozens of images to fewer, larger projection units that offered only needed video and computer images in varying sizes.

Method of System Implementation—Procurement

Effective management is key to acquiring the right facility, systems, and services at a reasonable price. The TMCs visited shared various experiences in ITS procurement, including—

- An important lesson learned in TMC procurement was that TMCs were unique facilities, and that architects and engineers who were unfamiliar with the particular aspects of TMCs, with how they were used, and with the devices and systems they contained would often make design errors, resulting in either operational difficulties or requiring expensive rework after the TMC was completed.
- Several TMCs reported negative experiences when software was developed at a remote off-site location rather than local to the TMC, but at least one TMC attributed its significant expense and difficulties to its local developer's lack of software development experience when the TMC required that its software be developed locally.
- One TMC described how important it was to have an independent "second technical opinion," allowing the TMC to avoid total dependence on the primary design or development consultant's opinion. Another TMC seconded that point, and added it had had significant success hiring specialist consultants for particularly complex areas such as fiber optic network design and geographic information systems. A third TMC added that it had found significant utility in hiring an independent inspection consultant who had previous ITS implementation experience.
- Two TMCs warned against accepting software that was less than satisfactory from the developer, thus losing leverage over the developer in resolving problems that would eventually plague operations and maintenance.
- Although customized commercial off-the-shelf software was viewed by some TMCs as a panacea, one TMC warned against assuming that accepting such a solution was faster, more reliable, or less costly than a more purpose-build system.
- Regarding contracting, one TMC warned that TMCs—if they fully understood what was needed—should buy their own hardware directly rather than through contractors or consultants to reduce cost, simplify warranty and maintenance management, and ease the process of replacing obsolete equipment.

Lessons Learned

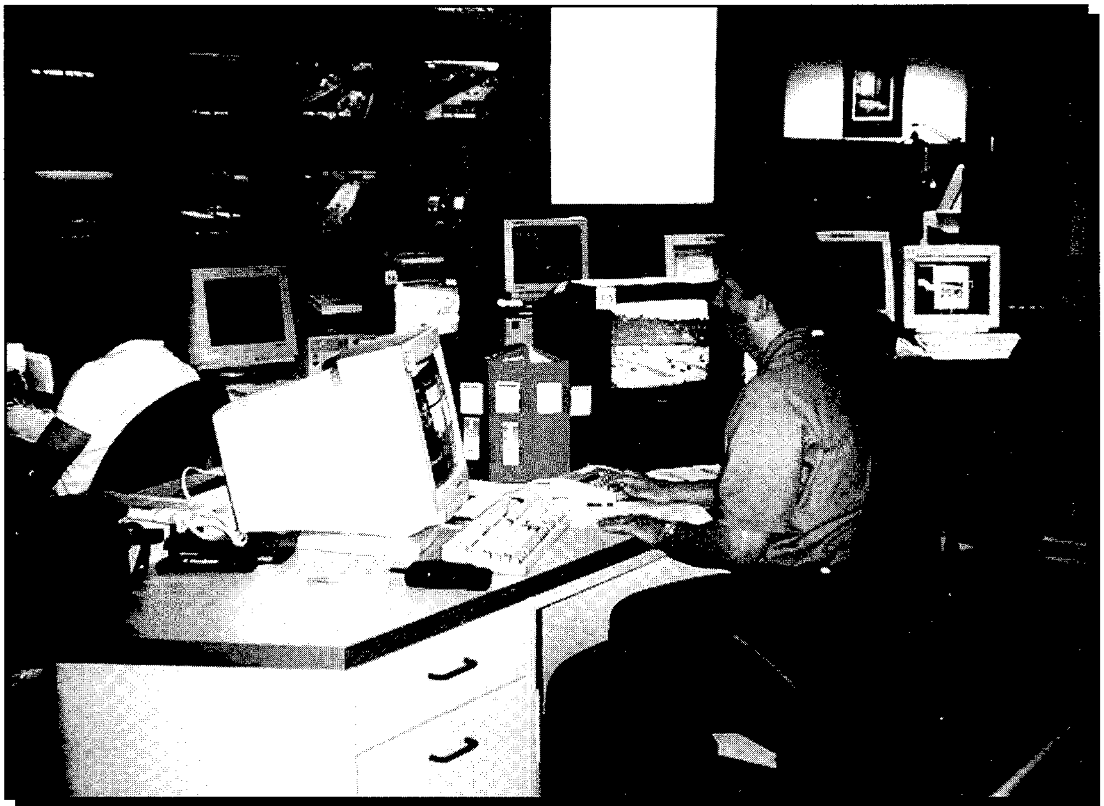
- One TMC, whose system had been built within significant time constraints by several contractors, noted the complexity of wide-scale integration of installations by multiple low-bid contractors. Another TMC commented that integration must be planned for—in budgets and in the implementation schedule—and that appropriate expertise (procured in an appropriate manner) must be retained if integration was to be successful.
- Yet another TMC discussed both the perils of having a general, non-ITS, contractor as the prime contractor in a systems contract and the inevitability of cost growth in a fixed-price, low-bid environment.
- TMCs essentially recognized the need for operations and maintenance to be involved in the request for proposal (RFP) development and design process.
- One TMC, involved in contracting for operations and maintenance, detailed how important it was to carefully and completely specify which services would be provided by the privatizer when privatization was being considered.
- One TMC shared its difficult experience in procuring key products and services as items "subsidiary to the bid." Placing no price or value on such items made it both difficult to ensure satisfaction and to change if the need should arise. Similar difficulties were experienced by one TMC that used very few bid items to procure its entire system.
- Mixing generic, performance, and detailed specifications in a single TMC acquisition led to difficulty in obtaining the desired flexibility while controlling the risk distribution within the project.

Training and Documentation

For operations, effective training and documentation ranked immediately behind hiring and staffing as critical priorities in ensuring effective operations. Some lessons noted included—

- Operations documentation that was not user-friendly hindered both the training of personnel and opportunities to ensure consistent, complete, quality operator performance.
- One TMC described its success in employing college students—under the guidance of an experienced senior operator—to develop additional procedural and system service material.
- Several TMCs mentioned the importance of specifying training for both systems and field equipment in the respective procurement documents.
- One TMC noted how important it was to specify the correct timing of training in field equipment procurement documents because training conducted too early or too late was of little value. The same TMC emphasized the importance of personnel receiving workable training materials with their initial training, so that personnel arriving later could come up to speed efficiently.
- One TMC noted that having an affordable tool that maintained thorough systems documentation as the advanced traffic management system software was modified was valuable. TMCs should also be aware of the ongoing need to update their design documents to reflect their systems' "as-installed" configuration. This need is supported by the TMCs receiving documentation electronically and in print from their software providers. A document development tool is equally valuable for supporting advanced traffic management system maintenance and improving TMC procedures as it is for basic systems documentation.
- Two sites mentioned the value of an effective online Help function, for both experienced and new operators.
- One site mentioned the importance of obtaining training in the operations and maintenance of special equipment within the TMC, such as the uninterruptible power supply (UPS), video switches, and the projection units.

Lessons Learned



System Operations

Workload and Performance—Staffing

The most difficult recurring challenges TMCs noted were related to operations and maintenance staffing.

- One TMC cited the importance of creating meaningful career paths within ITS for its operators, while another noted that agency policies, including unclear job descriptions, low pay rates, and stringent hiring qualifications, created major difficulties in hiring qualified operations personnel.
- One TMC's management believed it was critical to have correct and adequate staff immediately, rather than waiting for the advanced traffic management system to be completed and accepted.
- The same center that had had excellent results in hiring operators from a local community college's traffic program added that retired engineers made poor operators.

Workload and Performance—Workload

Two sites addressed operator workload issues.

- One TMC stated that it was easy to underestimate the operator workload from multiple tasks, particularly when such tasks were outside the traditional traffic management role.
- The other site discussed the significant workload that could result from manual logging, which it was addressing by investigating voice logging and use of automated recording of incident video.

Operations also provided several important lessons learned regarding its role within the traffic management process, including—

- TMCs that had begun interim, partial (or "beneficial use") operations before conducting final system testing and acceptance discovered such operations were frustrating. In addition, their contractors were concerned about the inefficient environment that such a practice created for testing and integration.
- TMCs cautioned against accepting software (either commercial off-the-shelf or software developed for another TMC) that had been inadequately customized to meet the individual TMC's unique operational needs.
- TMCs noted the operation of separate, unintegrated systems, i.e., legacy and new, was frustrating and inefficient.
- TMCs noted they received negative public reaction in response to an extended nonoperational period of variable message signs, primarily due to a misperception that the variable message signs were installed but not working.
- Many TMCs noted the value and importance of motorist assistance patrols to the overall incident and congestion management process.
- Several TMCs noted they received periodic calls from police officers at the scene of incidents requesting information about traffic conditions extending beyond their view of the incident scene. This information—which TMCs could often easily determine from the closed-circuit television cameras covering areas surrounding the incident—often helped the officer understand the extent of the queue behind the incident and the officer's alternatives for rerouting traffic at the head of the queue.

- Several TMCs noted the value—both in analyzing TMC performance and in identifying opportunities to improve traffic conditions—of having easy access to the traffic and activity information that the advanced traffic management system logged automatically. One TMC added that advanced traffic management system data should be retained for extended periods. That site had archived detailed traffic data on compact disks (CD)—one per month—since it opened, and another had had instances where 5 years of data were analyzed (to answer traffic flow questions that arose).
- Most TMCs did not plan how they would operate under emergency conditions or how they would manage the road network in emergencies. One site that had experienced an unusual weather emergency in the past year strongly urged that all TMCs plan for emergencies, and that those plans be revisited regularly. It was observed that TMCs where emergency conditions were more common might have multiple emergency scenarios (e.g., hurricane, refinery fire, flooding).
- Although tours were an important component of outreach to many audiences, several TMCs commented on the significant disruption from such visits. Often tours began before system acceptance and created disruption of not only agency activity but of the work being performed by the system integrator and testing teams.

Workload and Performance—Computer Systems

Issues TMCs noted regarding computer systems operations included—

- Requiring operators to enter address-based incident locations into the system was inefficient.
- Representing long-term construction lane closures as incidents within the system was inefficient. It was suggested that closures should be shown differently, perhaps as a separate icon color on the system map.
- Although the computer systems captured a great deal of information, that information was useful only if it was readily accessible, using retrieval and reporting tools that were convenient and easy to use.

Both operations and maintenance personnel recognized the significant value of effective automated detection and reporting of faults in field equipment by the central computer system.

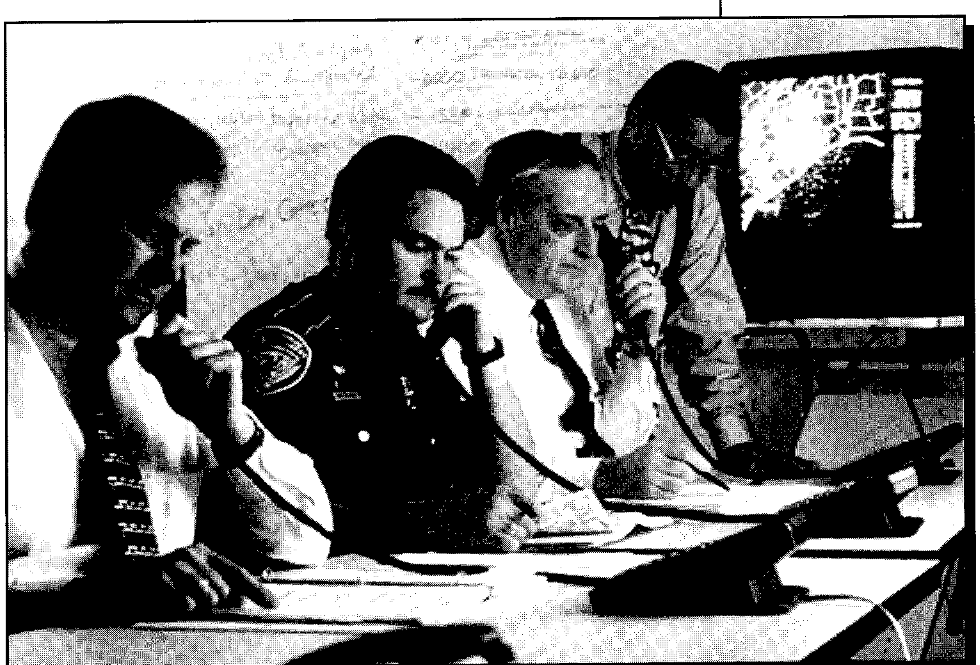
Coordination

The study team identified several lessons learned for organizing effective TMC operations and maintenance, including—

- The most common problem TMCs cited was a lack of close coordination between operations and maintenance if the two were located in organizationally separate parts of an agency.
- At a fundamental level, agencies should carefully consider where the TMC belonged organizationally within the agency to work effectively, especially if the TMC was delivering statewide services. Decisions on where to place the TMC—as each department within the agency or district statewide would have differing overall goals and objectives, varying access to key resources, and distinct support from or access to key decision makers—could greatly influence the TMC's progress.

TMCs expressed the following differing opinions regarding the importance of a separate Information Technology team supporting their operations.

- One TMC cited a gulf between its information technology team and TMC operations, even though both belonged to the overall TMC organization.
- In another case, the TMC information technology team was hailed as the source of salvation in reducing system problems to a workable level and in gaining from systems consultants the functions that TMC operations desired, delivered in ways that TMC operations could easily use.



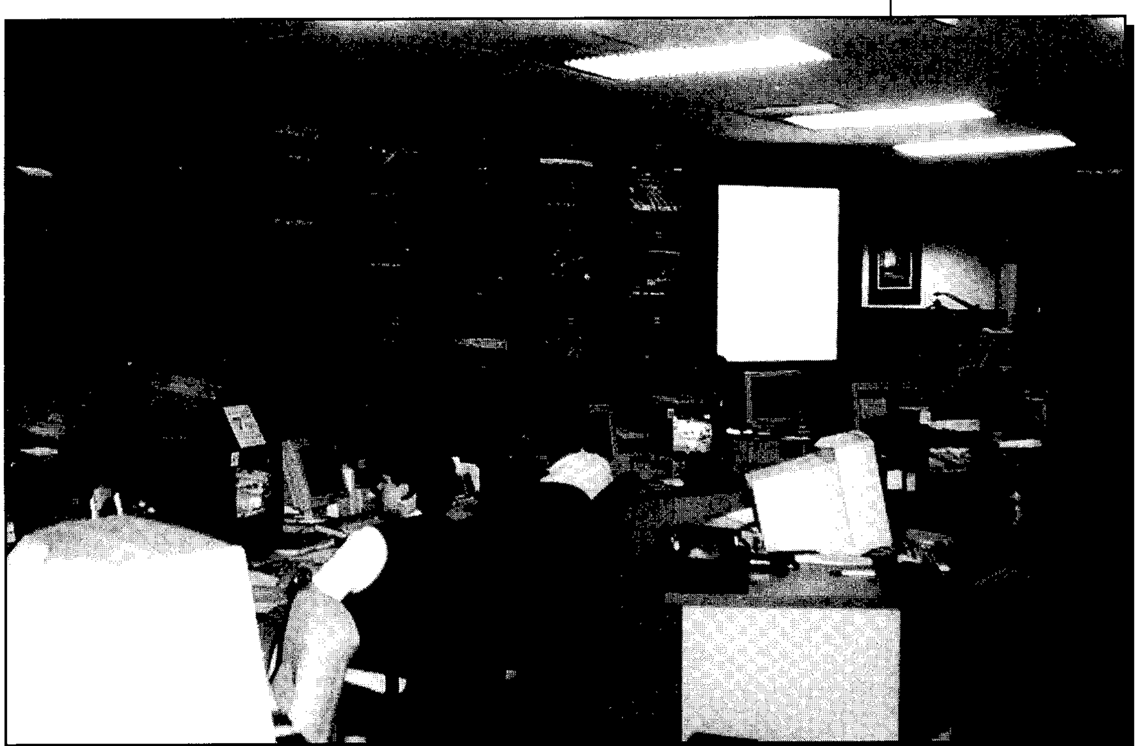
Lessons Learned

System Maintenance

Both TMC operations and maintenance offered lessons learned for maintaining ITS, including—

- A significant difference between services covered by "warranty" and "maintenance" existed, and TMCs should be quite clear which was desired before contracting for either. For example, warranties typically did not include repairs of damage from weather, vandalism, improper operation, or vehicle impact. The amount and type of preventive maintenance performed under a warranty was typically at the discretion of the warrantor. The type of service (return for repair vs. repair/replace in place) also varied depending on the specifics of the warranty contract.
- Many TMCs encountered significant difficulty in their attempts to obtain parts for legacy systems. Planned upgrade programs and development of workaround solutions could lead to significant savings and improve system reliability.
- Integrating the maintenance tracking system with the advanced traffic management system usually increased the efficiency of the interaction between operations and maintenance personnel in the identification and resolution of device failures, and in bringing devices back into use after repairs had been completed.
- Operations staff members frequently determined the status of field devices by referring to their workstations. In doing so, the best possible traffic management solution, given the available and operational field devices, was applied for each traffic situation.
- Both operations and maintenance experienced difficulty when using leading edge technology that was more difficult to update because it required specialized skills and was less stable and proven in traffic management applications.

- Several TMCs used or contracted their maintenance support. As with other types of contracting support, the TMCs had several lessons learned, including—
  - TMCs expressed the need to have contract support personnel located on site to gain the desired value from their efforts
  - Maintenance contracting by low bid with no prequalification was particularly perilous, because much was left to chance in acquiring an effective contractor. TMCs also noted how important it was to carefully specify all skills required because general contractor categories (such as electrical contractors) might not offer a full set of the needed skills (such as communications technology). One TMC was also specifying the types of equipment required for maintenance, having experienced situations where its contractor did not have appropriate bucket trucks to safely reach the installed equipment.
  - One site mentioned that it had to oversee the traffic control and safety practices of maintenance contractors to ensure that appropriate regulations and practices were followed.
  - One TMC received superior results in separating its maintenance contracts based on the type of device being maintained, with one contractor supporting variable message signs maintenance and the other supporting other devices.



Issues

A core set of issues challenged each TMC visited for the study. Each TMC was addressing its core issues, with different TMCs often applying different solutions. Because the common issues concern concepts that are critical to the future of all TMCs, they are highlighted as follows:

Issue 1: Ensuring an adequate staffing level and budget for TMC operations and maintenance.

Even for TMCs where adequate funding was provided, often agencies had adopted policies limiting the number of full-time agency personnel. Although many TMC functions could be performed by temporary or contractor personnel, most TMCs cited the need for a core set of agency personnel to lead, perform, or oversee the TMC's primary functions. Lack of adequate agency staff, in the appropriate classifications, and with the right skills, caused ongoing stress in achieving the TMC's goals and objectives. That issue was even more severe when the TMC was being pressured to reduce its cost and staffing, often while duties were being expanded, and when additional centerline miles of road network coverage by the advanced traffic management system were being implemented.

Issue 2: Losing qualified TMC maintenance personnel to the private sector.

This issue combines multiple challenges—noncompetitive pay rates, career progression, and limited training and skill opportunities. The maintenance skills a TMC requires of its personnel, particularly for computer systems and communications, are in high demand by the private sector (and in one case noted, by other local agencies). Effective TMC maintenance, including its field equipment, is critical for ensuring the TMC's ability to perform its duties and functions.

Issue 3: Addressing technological evolution and obsolescence.

The use of technology by the typical TMC requires skills from a significantly different paradigm than those required for implementing roadways. The usable lifetime of TMC technologies and their need for active maintenance differs greatly from traditional road infrastructure. For example, an agency would be considered foolish if it began replacing road surface a year or two after paving it, yet not replacing computer hardware frequently might condemn the TMC to extremely limited functionality, rapidly escalating cost, and increased difficulty in obtaining support and replacement parts.

Issue 4: Estimating the time it takes for a TMC to become operationally stable.

In many cases, it appeared that unrealistic expectations were set for the time frame necessary to proceed from TMC system design through implementation to stable operation. Most TMCs have since learned that their computer systems (even if designed, developed, and integrated by experienced integrators) will require continual fixes throughout the first few years after acceptance.

Issue 5: Mitigating false alarm rates.

Regardless of substantial progress in improving incident detection algorithms, most TMCs depended on other methods to detect incidents. Although the direct access of some TMCs to cellular 911 and incident reporting calls (i.e., DOT) mitigated the false alarm problems, not all TMCs had such access.

Future Directions

Based on discussions with TMC leaders during the study, several future directions for TMCs appeared to emerge as follows:

Direction 1: Fully integrated workstations.

Consistent with human factors research in similar areas, most TMCs wanted to monitor or control all their devices and information from a single workstation. Older, less integrated systems (such as those requiring multiple computers or control panels to fully investigate or respond to an incident) were commonly recognized as less productive and as requiring more maintenance.

Direction 2: On-site integration of agencies.

Opinion regarding the need for the physical presence of multiple agencies in a single TMC or whether multiple agencies interacting via a "virtual TMC" could achieve equivalent results varied significantly. However, the overall opinion appeared to be that when agencies worked together in the same physical facility, more was achieved.

Direction 3: Integration of freeway and arterial control.

During the survey, existing TMCs were increasingly recognizing that the full benefits of transportation management were achieved only when control of freeways and surface streets was performed in an integrated manner. Although integration typically required coordination across agency lines, performing integrated total network management was viewed as desirable by almost all TMCs. Based on existing experience, that integration would likely include placement of closed-circuit television and variable message signs on arterials and control of ramp metering and signal timing.

Direction 4: Integration of traffic management and transit.

TMCs, having made great strides in developing cooperative relationships between traffic management and law enforcement, noted the next major area offering great benefit would be a similar integration of traffic management with transit. Houston noted that, although no formal procedures existed for interaction between traffic operations and transit, much traffic information was passed back and forth between the TMC-based dispatchers and buses. Houston stated it would be investigating the possibility of information transfer between its computer-aided dispatch system and its advanced traffic management system.

Direction 5: Preventive and reactive traffic management.

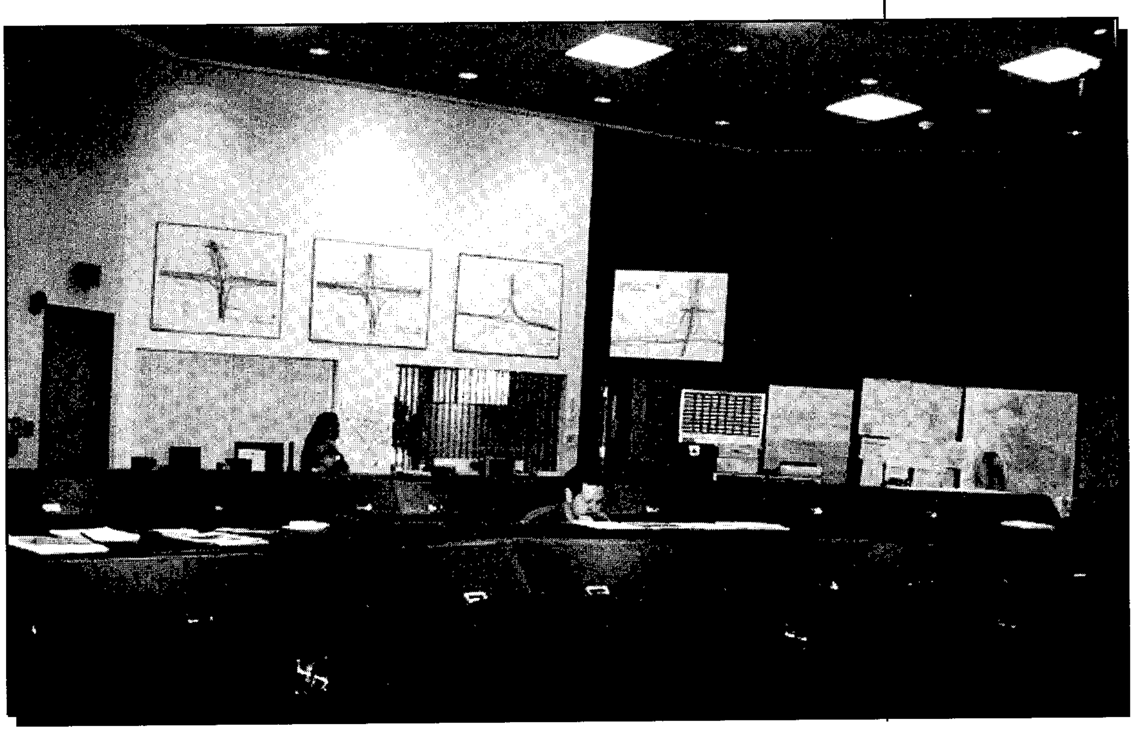
Many TMCs reacted effectively to incidents or congestion that already existed. However, an increasing number of TMCs planned to provide information to motorists that would allow motorists to avoid anticipated problems and would help the TMCs balance the flow among the various available road network components. This goal would achieve even greater success if pursued in combination with Direction 4 by accomplishing mode shifts when known travel route and mode combinations were expected to be highly congested.

Direction 6: Increased operator support from the workstation.

Future workstations will be expected to provide increasingly integrated sources of support for existing TMC functions. TMC operators and leaders will also be expected to use single workstations that provide support for various other operator functions, such as report generation or assisting in equipment maintenance. The increased integration of operations and maintenance functions within a single workstation is a highly desired goal, even as the level of automation support to maintenance increases rapidly.

Direction 7: Contract or privatized operations and maintenance.

The desire for downsizing government is forcing TMCs to do more with less. TMCs, based on federal experience with successful service contracting (including many years of contracting for consulting services), are increasingly likely to hire contractors to provide most TMC operations and maintenance activity.



Conclusion

A TMC is a highly visible element of a transportation management strategy, and it is critical in generating successful results from the investment in public infrastructure. In this study, the Concept of Operations has been used as a tool to investigate the differences in approach between TMCs in the United States and Canada, and to gather and organize best practices, lessons learned, common issues, and future directions. The purpose of gathering and disseminating this information is to provide existing TMCs with ideas for improvement of their own operations and to provide agencies implementing new TMCs with input to their implementation process.

A comparison of the methods used in the eight TMCs that were examined shows that there are multiple effective approaches in the operation and management of the TMC and the resources under its control. This diversity of approach allows each TMC to address the specific transportation needs of its geographic area, applying the policies, procedures, and resources that are made available by its participating agencies. Although various challenges facing many of the TMCs are yet to be resolved, both policy and technology evolution will continue to offer opportunities for improvement of the TMC and its Intelligent Transportation Systems program.

A valuable reference in planning and executing operation and management of Intelligent Transportation Systems assets is the Institute of Transportation Engineers Recommended Practices for Operation and Management of Intelligent Transportation Systems which were completed in mid-1998. These practices were developed during a 3-year period by panels of Intelligent Transportation Systems practitioners. Although they have significantly broader applicability than only TMCs, the recommended practices were compared to the findings of this document to ensure that all relevant topics had been addressed.

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Notes

Metropolitan Transportation Management Center

A CASE STUDY

Boston Central Artery/Tunnel
Integrated Project Control System

Responding to Incidents Rapidly and Effectively

October 1999

Foreword

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Program Manager, Operations
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NOTICE

The United States Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear herein only because they are considered essential to the objective of this document.

Preface

The following case study provides a snapshot of the Boston Central Artery/Tunnel Integration Project Control System (IPCS) operations control center. It follows the outline provided in the companion document, *Metropolitan Transportation Management Center Concepts of Operation —A Cross Cutting Study,* which describes operations and management successful practices and lessons learned from eight transportation management centers in the United States and Canada.

This case study reflects information gathered from interviews and observations at the IPCS operations control center. The authors appreciate the cooperation and support of the Massachusetts Highway Department, the Massachusetts Turnpike Authority, and their partners in the development of this document.

Contents

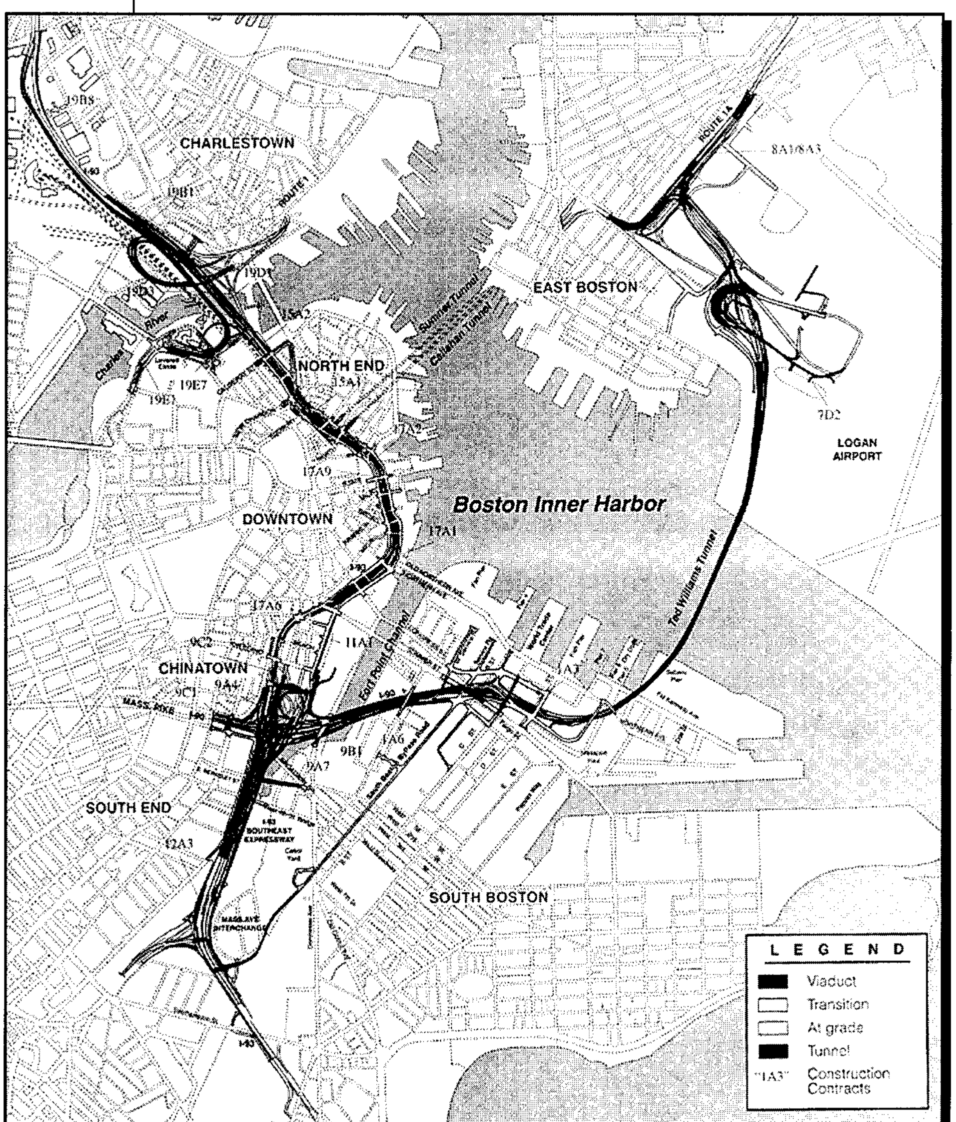
Background

The Integrated Project Control System (IPCS) is an integrated traffic management and system control and data acquisition application for Boston's 7.5-mile Central Artery/Tunnel. The project, locally refered to as "The Big Dig," will cost $73 million to implement both the operations and backup control centers and the first 1.5 centerline miles of system. The system features a high density of field equipment, and double or triple redundancy in many elements.

The traffic management components of the IPCS also support travel through the heart of Boston and to and from Logan Airport.

The objectives of the Integrated Project Control System are to:

- Monitor security, traffic, and systems status
- Respond to incidents, nonstandard needs, or equipment failures rapidly and effectively.



Design and Implementation

General system design parameters for Integrated Project Control System are the following:

- The Integrated Project Control System operations control center is located in a new $20 million building at the entrance to the Ted Williams Tunnel. Features of the the 40-foot by 60-foot control room include:
  - Two rows of five operator positions each
  - Video wall display with eighteen 90-inch diagonal rear projection units plus 54, 21-inch video monitors.
  - Each operator has a dual, 19-inch monitor, single workstation and six 13-inch video monitors
  - A backup operations control center with four operator positions and 70 monitors is located nearby. All critical functions of the operations control center can be performed from the backup operations control center. Both are connected to the system's dual counter-rotating ring fiber optic network.
- The computer software is an adaptation of a commercial system control and data acquisition package, running on a DEC Alpha 450 MHz processor with the VAX/VMS operating system. The primary processor fails over to a fully redundant secondary processor at the operations control center, and then to a tertiary processor at the backup operations control center. Operator workstations are Pentium class personal computers running the Windows NT operating system.

With its unique location and mission, the Boston IPCS demonstrates the benefits of a transportation management center that integrates downtown, airport, and seaport facilities.

Design and Implementation

IPCS ensures operational readiness under frequently changing road conditions by using desktop rehearsal and new or altered procedure simulations.

The system features include the following list:

- Loop detector stations at 200 feet in every lane
- More than 500 closed-circuit television cameras providing fully redundant camera coverage of the entire road area
- 120+ variable message signs on the freeway and surrounding arterials
- Lane control signals
- Highway advisory radio
- Full AM/FM rebroadcast in tunnels
- Motorist callboxes
- Full cellular phone coverage within the tunnels
- Flashing beacons
- Variable speed limit
- Detection of vehicles overheight for the tunnel.

Method of Implementation

- The initial Integrated Project Control System concepts were developed by Massachusetts Highway Department in two concept reports. The recommendations set forth in these reports were followed when creating the preliminary design. These were included in the Environmental Impact Statement, making the implementation of these design recommendations a formal agency commitment. Final plans, specifications, and estimates were developed by a consultant, and a construction contract was awarded through a two-step procurement process for the first phase of the system.

Testing

- Six months of initial system testing was performed at the vendor's California facility by vendor personnel, witnessed by Massachusetts Highway Department and its consultants. Three additional months of testing was performed after a significant processor upgrade.

Operations Readiness Testing

- The backup operations control center can be used for testing system modifications before they are brought online at the operations control center.

Training

- The Integrated Project Control System developer provided initial training to operations personnel. Refresher training is provided periodically, including updated training in new system functionality or for new operational methods.

Documentation

- Training resources include system manuals, operations and maintenance manuals, and standard operations procedures.
  The system objective is to have an operators response manual available online and in print.

Operations

Workload and Performance

- MassPike is the operations and maintenance contractor to Massachusetts Highway Department, the system owner.
- New personnel must pass qualification tests in specific skills areas for each level.
- The Integrated Project Control System features one of the more extensively automated operations systems in the United States. Cameras will be triggered to display violation-of-speed/occupancy thresholds; otherwise video monitors are blank. Congestion and suspected incidents are automatically alarmed at operator workstations. Operators can bring any image to any monitor. The system map will display the entire road network or 1,000-foot roadway segments. Every system device is represented on the map by an icon that can be used both to determine device status and to control the device.
- Systems operations are 24 hours a day and 7 days a week, with a total staff of nine operators and a supervisor (two operators on each shift). Shift overlap is 30 minutes. Shift-change procedures include use of a "pass-down log" that documents shift activities that will affect the next shift, a shift change log of items checked at the beginning of each shift, and a "closeout log" that determines which problems have been resolved.

Coordination

- The Central Artery/Tunnel maintains its own response units that respond to any need within 3 minutes from detection to arrival at an incident scene. Direct radio link to the nearby state patrol is maintained on the operator console. "Hot Line" telephone links to 17 partner agencies, including law enforcement, are supported. Weekly meetings are held with core partner agencies.
- There are plans to eventually implement the Massachusetts Highway Department's Boston regional TMC in a room adjacent to the operations control center.
- Integrated Project Control System provides video and traffic information to partner agencies for their own use. A local information service provider is currently seeking an interface to Integrated Project Control System information and video for dissemination.

Operations

- Transit integration with the Integrated Project Control System Interim Operations Center is not extensive. Current information exchange is focused on telephone calls between the Massachusetts Bay Transit Authority and the Interim Operations Center when major incidents are detected. Massachusetts Bay Transit Authority is presently implementing automatic vehicle location, which would allow its vehicles to function as traffic probes, and has expressed an interest in access to Integrated Project Control System video. Discussions of future activity have included the possibility of moving Massachusetts Bay Transit Authority bus dispatch into the regional transportation management center which will adjoin the Integrated Project Control System Operations Control Center. Massachusetts Bay Transit Authority is also working with the City of Boston on an upgrade to its traffic signal controllers which will provide access to congestion information at each signalized intersection.

Conflict Resolution

- Decision authority is from operator to operations supervisor to partner agencies. The operations supervisor is available by pager and cellular telephone when not on duty.

Nonstandard Operations

- For planning and operations in special and emergency conditions, Massachusetts Port Authority and the Central Artery/Tunnel have war rooms.
- Integrated Project Control System will have an individual assigned for special event and weather emergency planning.
- Operators are involved in special events planning.
- Before a special event occurs, Integrated Project Control System suggests planned procedures to relevant agencies.
- There is a formal review of data on previous special events, including lessons learned.
- Given the significant number of area road closures due to construction, Integrated Project Control System meets weekly with Central Artery/Tunnel program team, other area agencies, utilities, and contractors.

Maintenance

Fault Detection and Correction

- Integrated Project Control System performs automatic monitoring and reporting of the status of all equipment. Device status is indicated by the color of the device icon on the system map. Operations has a direct line to maintenance. Because portions of the system and field equipment are available only to Integrated Project Control System on a "beneficial use" basis (i.e., not formally accepted; still under the responsibility of the contractor), operations may also contact the contractor.

Configuration Management

- The configuration management database is maintained in the maintenance management system. The implementation contractor provided the configuration baseline.

Logistics

- Spares, tools, and test equipment will initially be supplied by the implementation contractor. MassPike will also maintain spares. Both will be located at a central location. An online maintenance management system will be used, including online maintenance manuals.

Maintenance

- MassPike is the maintenance contractor to Massachusetts Highway Department. Under its 18-month obligation, the installation contractor provides system updates, preventive maintenance, repairs, and training during this period. At the completion of the 18-month support period, Massachusetts Highway Department and MassPike plan to contract for maintenance using a multi-year renewable contract. Massachusetts Highway Department and MassPike are considering a combined operations and maintenance contract.

Due to the life-critical nature of tunnel traffic incidents, the IPCS implemented rapid incident response programs and highly reliable systems.

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Metropolitan Transportation Management Center

A Case Study

COMPASS

Effectively Managing Traffic and Incidents

October 1999

Foreword

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NOTICE

Preface

The following case study provides a snapshot of the Downsview, Ontario transportation management center (TMC). It follows the outline provided in the companion document, *Metropolitan Transportation Management Center Concepts of Operation — A Cross Cutting Study,* which describes operations and management successful practices and lessons learned from eight transportation management centers in the United States and Canada.

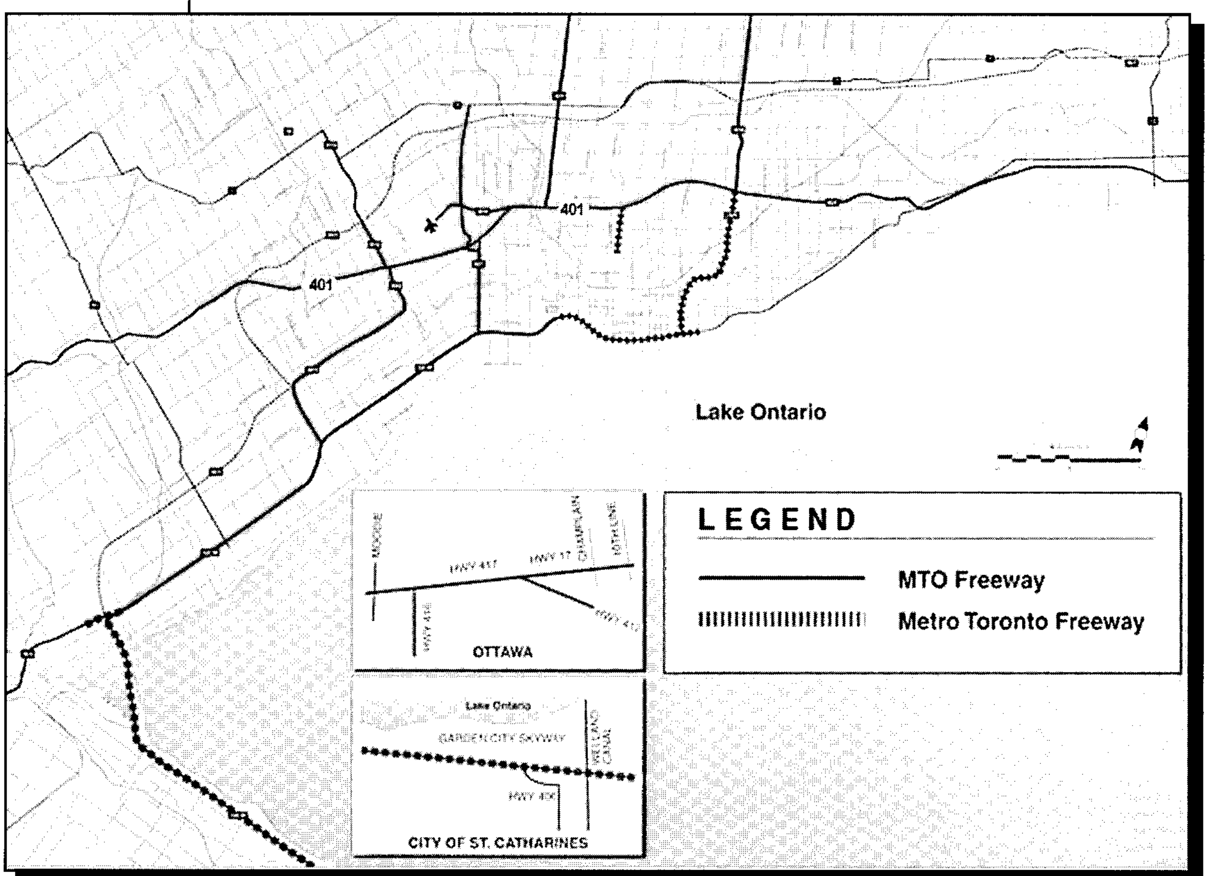
This case study reflects information gathered from interviews and observations at the Downsview transportation management center. The authors appreciate the cooperation and support of the Ministry of Transport Ontario (MTO), and its partners in the development of this document.

Contents

Background

COMPASS is the transportation management program of the greater Ontario area which contains three transportation management centers, each responsible for a separate segment of highway. This study focuses on the TMC in the Downsview section of North York, Ontario. The Downsview system covers Highway 401 as it enters and proceeds through Toronto from the west. The preliminary design was completed in the late 1980's, and the system became operational in 1991.

The initial objective of the Downsview system was to balance traffic between express and collector lanes on Highway 401. Incident detection and incident management were added to the design. COMPASS has recently completed a value engineering study that allowed a complete review of the initial principles.



Design and Implementation

General system design parameters for Downsview are:

- The 45-foot by 40-foot Downsview control room is in a Ministry of Transportation Ontario (MTO) office building about one block north of 401. The control room is configured in the following way:
  - Three curved rows of consoles, with the first containing five positions, the second a team lead, and the third (elevated) three positions, typically used by the operations supervisor.
  - The room front has 69 19-inch monitors.
  - Each console features typically two 13-inch monitors, two computer terminals (for different systems), a video control panel, and a multiline desk phone.
  - Two maintenance radio consoles.
  - Glass block construction on one side provides outside light.

- The operators detect incidents and congestion based on computer alarms, scanning of video images, and incoming telephone and radio calls. They verify incidents with closed circuit television cameras, and then identify the incident or congestion location and the type of incident to the computer system. The system recommends specific messages for specific variable message signs. Variable message signs carry congestion management messages automatically. A separate system faxes traffic information automatically to an appropriate list of agencies and other organizations. Operators also have access to a Road Weather Information System monitor.
- The present system contains variable message signs, loop detectors (0.3 mile intervals, in every lane), and color-closed-circuit television cameras. Communication is over a fiber optic network.

COMPASS began as a traffic load/flow balancing program and later expanded to include incident management, thus increasing the positive impact on traffic flow.

Method of Implementation

- Following the preliminary design report, a detailed design was prepared by consultants and agency staff. Software was developed externally under a consulting agreement. Field equipment was installed under multiple construction contracts, overseen and inspected by consultants and agency personnel. Agency personnel performed final integration.

Design and Implementation

Testing

- Consultant and agency personnel do testing at the manufacturer's site and after field installation. Agency personnel perform operations readiness testing.

Training

- Operator training is primarily on the job. Additional training is provided when system expansions occur and when operational procedures change. New operators are assigned to work briefly with maintenance and at Ontario Provincial Police dispatch.

Documentation

- Operators are provided an operations procedures manual that contains information on:
  - System purpose, background, objective, and overview
  - Job descriptions, conduct, security, shift start and end procedures
  - Changeable message sign operation and policy, incident detection
  - Closed circuit television cameras and taping
  - Detector placement, use of computer terminals and Road Weather Information System
  - TRIS (traveler and road information system) policy
  - Driver and vehicle terminal, communications, and incident management protocols
  - Media, general public, Ontario Provincial Police liaison, and liaison with other COMPASS and Ministry of Transportation Ontario staff
  - Radio system protocol, hardware failures procedures, phone directory, and use of operational documents.
- Other documents provided to operators include:
  - A patrol list providing patrol coverage and methods of contact
  - A technical and electrical binder listing applicable personnel, methods of contact, and Ministry of Transportation Ontario signal locations
  - A nuclear emergency/provincial emergency manual
  - Drawings of equipment locations and IDs
  - Emergency telephone numbers
  - Construction contract listings of projects and contacts
  - A driver and vehicle binder providing numbers for Ministry of Transportation of Ontario Commercial Vehicle Operations staff
  - A service crew binder providing maintenance contacts and emergency operator contacts, including emergency services, automobile clubs, and road agencies.
- The computer system Help function is procedurally oriented.

Provincial and metropolitan governments continue to develop ways to increase integration and coordination between COMPASS and RESCU operations.

Workload and Performance

- The Downsview TMC is staffed 24 hours a day, 7 days a week in three shifts with 1-hour team lead overlaps. Peak period shifts include three operators and a shift supervisor. Staffing totals 12, including three part-time personnel, two team leaders, and one supervisor.
- Communications logs are maintained continually. Videotaped incidents are logged separately. The system automatically logs actions implemented through the system. Various statistics on workload are compiled and analyzed.
- Primary sources for hiring include students from a local technical college with a program in transportation and other parts of Ministry of Transportation Ontario, drawing on surplus or laid off personnel. Ministry of Transportation Ontario has recently prepared a study of hiring sources and backgrounds.

Coordination

- Interface with Ontario Provincial Police is via telephone to Ontario Provincial Police dispatchers; all other emergency services are contacted through Ontario Provincial Police. Ontario Provincial Police and local law enforcement agencies request continuous taping of areas with special problems, as does the traffic engineering office of the Ministry of Transportation Ontario . Debriefings are held with Ontario Provincial Police and other involved agencies after major incidents. There are also twice-annual senior level meetings between Ministry of Transportation of Ontario and Ontario Provincial Police.
- COMPASS contacts both the Toronto Transit Commission and GO transit operations centers by telephone in the event of major incidents, and provides faxes of lane closures and incidents to both agencies. Since Toronto Transit Commission buses do not use Highway 401, which is the focus of COMPASS, further integration is not of significant value to either program.
- Work is under way to share video with the city's RESCU system and to address common variable message sign messaging approaches.
- Media receive fax output as do all other relevant agencies at no charge. View-only video access is provided to media for a subscription fee of $500 per month.

Operations

Conflict Resolution

- On-site decision-making authority passes from operators to operator team leads to the shift supervisor to the operations manager (on site). Section heads for design and construction are also on site, and maintenance is nearby. Key personnel are accessible by pager and cellular telephone.

Nonstandard Operations

- Special events do not have much impact on the freeway system, and thus do not create a significant workload. However, about a half-dozen major snow storms occur per year.
- The conference room adjacent to the control room has been outfitted as an emergency operations facility, with separate communications lines, video, and computer access.

Fault Detection and Correction

- To represent a malfunctioning field device, the computer workstations provide both messages and special symbols or changes in icon color on the system map. If a failure occurs, Operations calls Maintenance or the computer support section and is able to restart some functions. Operations also notifies the illumination and signal departments of signal, flasher, or illumination failures.

Configuration Management

- Maintenance has created its own configuration database. Information on newly installed equipment is provided by the installation's contractor. The database is maintained by the systems group within the maintenance organization.

Logistics

- Most spares are supplied via installation contracts, and additional spares are acquired through construction contracts. Ministry of Transportation Ontario returns failed units to manufacturers for repair. Ministry of Transportation Ontario is able to buy spares directly from manufacturers.

Maintenance

- Maintenance uses a preventive maintenance program developed by a consultant and regional design group.
- With current installation contracts, Ministry of Transportation Ontario requires 2 to 3 years maintenance by the contractor, including preventive maintenance but excluding weather and traffic damage. Training is procured through the installation contracts.
- Some maintenance work, including support of the variable message signs and the fiber optic communications network, is contracted, with a trend toward increasing such contracting. However, Ministry of Transportation Ontario systems staff members maintain the computer system.

COMPASS has implemented an on site emergency operations center, enhancing interagency coordination under emergency conditions.

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Metropolitan Transportation Management Center

A Case Study

Houston TranStar

Maximizing Safety and Mobility for the Public

October 1999

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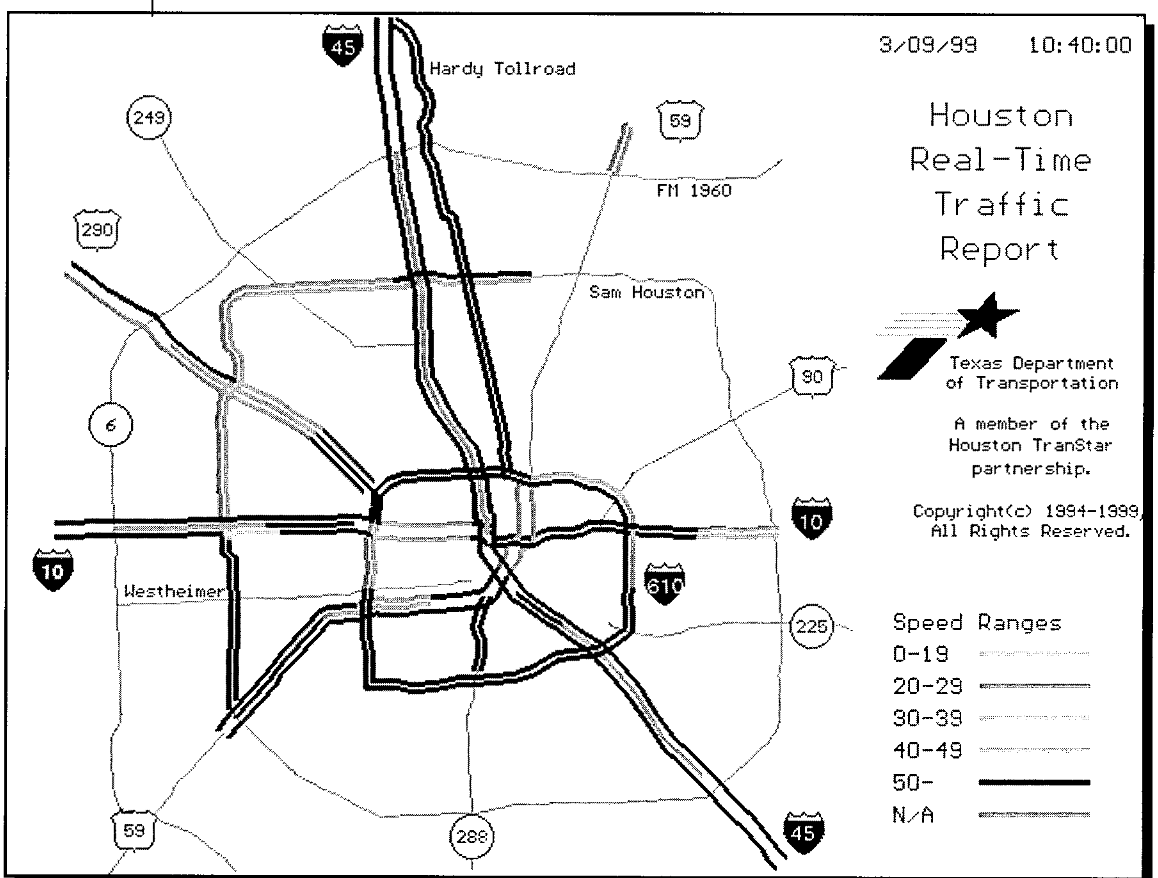
Contents

Background

Houston TranStar is a multiagency transportation management center (TMC) providing traffic management, traveler information, and emergency management for the greater Houston area and Galveston. Agencies involved include the Texas Department of Transportation (Tx DOT), the City of Houston, Harris County, and Houston Metro. (Houston and Harris County Offices of Emergency Management are also present.) The facility opened officially in April 1996, although interim operations had been under way since December 1995 (and earlier in an interim leased facility).

The mission of Houston TranStar is to maximize safety and mobility for the public. The objectives include the following:

- Manage emergency response
- Promote emergency management awareness and public safety
- Promote the benefits of Houston TranStar
- Increase efficiency and improve productivity
- Increase mobility, manage congestion, and enhance safety.



Design and Implementation

General system design parameters for TranStar are the following:

- The control center is a 54,000 square-foot facility located on the west side of Houston, with immediate access to I-10 and the I-610 beltway. There are roughly 75 prime-shift personnel in the facility. Expansion of the facility is being considered to accommodate additional components of the four core agencies. Cost for the center and its contents (including Advanced Traffic Management System software) was $13.7 million.
- A typical operator console has a computer workstation with two 19-inch monitors, four 9-inch video monitors, communications panel with stalk microphone, and a telephone. The front of the control room features four 120-inch video screens, which can be divided into multiple images.
- TranStar resources include variable message signs, highway advisory radio, loop detectors, closed circuit television, lane control signals, ramp meters, a motorist assistance patrol, and an automatic vehicle location-based congestion detection system extending beyond the detectorized area. An extensive (3,000 intersection) traffic signal system upgrade/replacement is also under way.
- Incidents are detected by visual monitoring of congestion level on the area map, through cellular 911 (to Harris County) calls, reports from law enforcement officers and the motorist assistance patrol, or by visual monitoring of scrolling camera images. Incidents are entered manually in the computer system, which logs all data received and actions taken. Operators can choose from categories of variable message sign messages, edit the messages, and initiate them for selected periods of time. Changes in lane control signals are implemented similarly. Highway advisory radio messages are created and recorded manually at a separate workstation. Video control is maintained from a separate control panel at the operator console.
- Traffic media have broadcast booths behind the control room.
- Houston METRO, the transit service provider in Harris County, Texas, is one of the four primary partners in TranStar. Its personnel perform bus fleet dispatch and management from within the TranStar control room, providing full access to all TranStar information and capability. METRO also performs project management, special events planning, HOV facility operation, and enforcement functions from TranStar.

TranStar operations and maintenance personnel work together to assess and repair field equipment.

Houston TranStar's TMC is staffed by city, county, transit, and state personnel who cooperate on all aspects of transportation management.

Design and Implementation

Method of Implementation

- Conventional design and construction contracts have been used for control center facility and field equipment implementations, with much earlier design done by Tx DOT personnel. The transportation management computer system was developed and supported by a consultant. The automatic vehicle location system was designed by Texas Transportation Institute, which operates and maintains it.
- Metro Traffic is being considered as the sole information service provider under a no-cost contract to the agencies.

Testing

- Integration occurs in three stages—device to communications hub, hub to control center computer room, and computer room to workstation. Testing is required in construction contracts; Tx DOT inspectors witness the testing.
- Operational readiness testing was performed by operations personnel, project staff, and the computer system developer. A test database exists to support such testing.

Training

- The computer system developer provided training for initial operations personnel. Training for new personnel is primarily on the job. Additional training is provided as new functions are brought online. Refresher training is performed. New operators take about 1 month to become efficient.

Documentation

- Memoranda outline operator roles and responsibilities. Operational procedures are developed on an as-needed basis. New procedures are prepared as new organizational units move to the control room.
- An indexed online Help function is available.
- "As-built" plans and equipment documentation for field devices are retained at the nearby Tx DOT district offices.
- The computer system provides an alphabetically indexed Help function with information commands, system functions, and use of the equipment.

Operations

Workload and Performance

- The system covers 108 centerline miles of interstate, with additional centerline miles monitored by the automatic vehicle location congestion monitoring system. Eventual coverage will be 160 centerline miles.
- The control room is staffed by most agencies 24 hours a day, 7 days a week; total morning peak control room staff is 14, including all agencies. Tx DOT traffic management stations are staffed in three shifts with a 30-minute overlap. Tx DOT has three traffic management operators during prime shifts and an additional dedicated operator for ramp metering. Tx DOT is responsible for freeway mainlanes, Houston Metro for HOV lanes, and the city and county for their respective frontage roads and arterials.
- Tx DOT operations personnel are involved extensively in determining field equipment status, communicating this information to maintenance, and verifying repairs.

Coordination

- Coordination between the agencies is mostly in person or by telephone. Agencies with field personnel communicate with them via two-way radio. Tx DOT dispatches contract wreckers by telephone.
- Although device responsibility is clearly delineated by agency, agencies share access to variable message signs and closed circuit television.
- County and Houston Metro law enforcement are located in the control room for direct interface.
- Tx DOT has retained a consultant to evaluate coordination and integration between the six control centers statewide.
- Tx DOT operations coordinates by phone and e-mail with Tx DOT maintenance, which is located nearby.

Conflict Resolution

- The TranStar organizational structure is unique. Operations personnel for each agency report to agency-specific on-site managers, who in turn report to a TranStar Leadership Committee, which reports to the TranStar Executive Committee. The role of the TranStar Director, funded jointly by the agencies, is primarily to facilitate interaction beween agencies. Managerial personnel are accessible by pager when they are off site.

Nonstandard Operations

- The facility houses a separate emergency management center from which emergency operations occur. Reports of emergency operations regarding major fires or severe weather cited outstanding benefits of collocating emergency and transportation management personnel.
- About 20 special events are planned by Houston Metro every year, including some lasting several days. Special events plans are extensive and detailed, incorporating inputs from many involved agencies.

Maintenance

Fault Detection and Correction

- The system automatically indicates the status of some equipment in which it detects loss of communication or malfunction by changing the device icon color on the system maps . Primary fault detection is performed by operations, who report via phone and e-mail to maintenance, and who receive reports of repair assignments and status.

Configuration Management

- The system contains a challenging number of different brands and models of device for each type of equipment. This increases the need for more technical expertise, additional stocking of spare parts, and continued efforts to test various devices.

Logistics

- Tx DOT maintenance uses an automated maintenance management system and e-mails equipment status and actions between operations and maintenance.

Maintenance

- Device warranties are required under most construction contracts. Tx DOT has also procured maintenance contracts for some equipment. The Texas Transportation Institute, which operates and maintains the automatic vehicle location system, also has subcontracted its maintenance.

TranStar staff prepare detailed transportation management plans for the complex and massive special events occurring in the Houston area.

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Metropolitan Transportation Management Center

A Case Study

Long Island INFORM

Identifying Incidents and Informing Travelers

October 1999

Foreword

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Christine M. Johnson
Program Manager, Operations
Director, ITS Joint Program Office
Federal Highway Administration

Edward L. Thomas
Associate Administrator for
Research, Demonstration and
Innovation
Federal Transit Administration

Preface

The following case study provides a snapshot of Long Island's INFORM transportation management center. It follows the outline provided in the companion document, *Metropolitan Transportation Management Center Concepts of Operation—A Cross Cutting Study,* which describes operations and management successful practices and lessons learned from eight transportation management centers in the United States and Canada.

This case study reflects information gathered from interviews and observations at the INFORM transportation management center. The authors appreciate the cooperation and support of the New York State Department of Transportation and its partners in the development of this document.

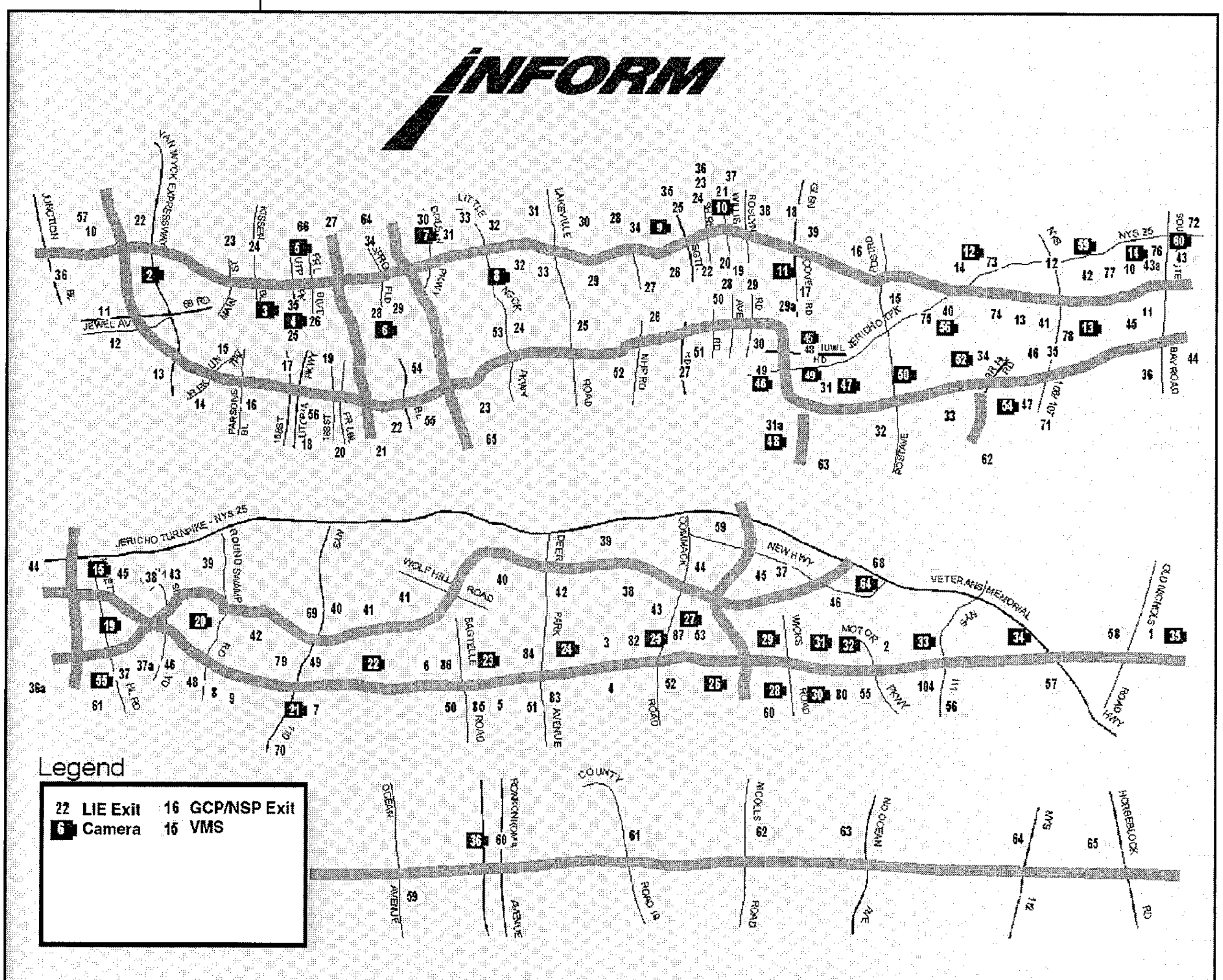
Contents

Background

Initial studies of traffic management on Long Island were done in the 1970s as part of the TOPICS program. Positive findings on the potential for such a system resulted in an initial $30 million demonstration deployment. The system was designed in the late 1970s and built in the early 1980s, containing variable message signs, ramp meters, traffic signals, and loop detectors, but no closed-circuit television. System operations went to 24 hours a day, 7 days a week in late 1987. Communications occurred over coaxial cable. The control center was located in the State office building in Hauppauge.

The objectives of the system are to—

- Identify traffic congestion and incidents or situations likely to cause congestion
- Provide information to motorists and incident management resources to minimize the duration and impact of incidents.



Design and Implementation

General system design parameters of INFORM include the following:

- The control center measures 65 feet by 45 feet, of which 25 feet by 25 feet is the control room. The control room contains:
  - A single row of operator positions with three positions facing three 100-inch LCD video wall units, one of which displays the system congestion map
  - Fifteen 19-inch color monitors are located at either side of the consoles; these are being replaced with multi-image capability on the video walls
  - Operator positions provide multiline standard desk telephones and deskphone style two-way radio units, 19-inch workstation monitors, and separate video controls.
  - The front console contains scanners for the three law enforcement agencies involved in freeway incident management.
  - Separate console positions at the rear of the control room operate the Highway Emergency Local Patrol function and the maintenance work logging computer.
- The system monitors and manages traffic on Long Island's three major east-west limited access routes. Work is under way to instrument north-south arterial connector routes. The original system covered 140 centerline miles of roadway. It is estimated that the completed system will add another 60 centerline miles, plus 40 to 50 centerline miles of arterials.

INFORM pioneered TMC operations contracting and continues to improve on its successful model.

Design and Implementation

The INFORM staff address the challenges of integrating legacy and modern intelligent infrastructure every day.

- Functions performed at INFORM include entry of incidents in the computer system, entry of variable message sign messages based on incident/congestion observations and reports, identification, logging, and requests for repairs of equipment failures, towing dispatch or request, and gathering and distributing information regarding construction and lane closures on the 1-800-ROADWORK telephone system to media and to other agencies. Monitoring of bridge scouring is being added to the INFORM duties. INFORM faxes information on travel delays and accidents every 15 minutes during peak periods to the 26 partner agencies and the media.

Method of Implementation

- The firm that performed the feasibility study later received contracts to design the system, develop and provide the computer system, and integrate the field equipment. A $5 million computer system migration contract was awarded to another firm several years later. Field equipment was installed under conventional low-bid construction contracts.

Testing

- Existing stand-alone test procedures are required for devices in all construction contracts. After installation of devices, the maintenance contractor connects them to the network, and the operations contractor makes software modifications and tests.

Training

- Training is mostly on-the-job. New staff are brought in for 1 to 2 weeks of training before they are formally assigned. First assignments are simpler tasks, then operators progress to more complex tasks, e.g. creating messages for variable message signs, which require a greater knowledge of the road network.

Documentation

- Motorist assistance patrol operators work from a motorist assistance patrol problems and procedures manual and a motorist assistance patrol standard operating procedures manual. Operations staff use an operators reference manual, intersection and diversion plans, and an operations manual.
- The system does not offer an online Help function.

Workload and Performance

- Contracted operations staff are present in the INFORM TMC 24 hours a day, 7 days a week. Three operators plus two motorist assistance patrol staff are present during peak hours. The operations contractor has a total staff of nine personnel plus three for motorist assistance patrols, including access to additional experienced personnel for absences and special needs. Shift-change procedures include a 15-minute overlap with manual handover and a shift-change checklist review.
- The current operations contract is INFORM's second nonprofessional services contract. Contract duration is 3 years with two 1-year extensions, at a value of $4.8 million for the first 3 years. The current contractor retained most of the first contractor's staff in place after award.

Coordination

- In addition to the six law enforcement agencies responsible for enforcement on roads covered by the system, wrecker services, and the relevant maintenance agencies, INFORM also coordinates with TRANSCOM. Fire and emergency medical services are contacted by telephone through the respective police departments. Motorist assistance patrol and New York State Patrol have "push off" authority. The motorist assistance patrol team contacts wreckers directly, or through police.
- TRANSCOM serves as the focus for sharing of information between INFORM and New York City Metropolitan Transit Authority's bus and rail control centers, and the distribution of this information to the public and to other agencies. New York City Metropolitan Transit Authority is implementing an automatic vehicle location system and a new automated train control system center which will provide real time vehicle location and arrival information. This information will also be provided to TRANSCOM, where it will be widely available through the iTravel metropolitan model deployment initiative's systems, along with extensive traffic condition information. TRANSCOM is also developing a video distribution network which will provide access to INFORM video to New York City Metropolitan Transit Authority control centers.

Operations

Conflict Resolution

- Incident response actions are initiated by a TMC operator. The decision making hierarchy for approval of actions requiring further authorization proceeds from the operator to the on-site contractor operations supervisor, the nearby operations contract manager, and ultimately to the on-site INFORM New York State DOT director.

Nonstandard Operations

- INFORM often becomes a central point for coordination during snow weather emergencies. It also serves as a focal point for the media, which reports from on site during such situations. The State emergency management center typically locates in the same building for snow emergencies.
- INFORM meets with State, county, and local city police to prepare for special events. It has established standard procedures for local agencies to request support from INFORM for smaller events. New York State DOT and INFORM also initiated a "Reach the Beach" traveler information program this past summer. The operations contractor supports some form of special event almost every week.

INFORM integrates traffic management on freeways and arterials across jurisdictional boundaries.

Fault Detection and Correction

- The computer system automatically senses detector, variable message sign, ramp meter, and communications failures and indicates them by a change in icon color on the system map. Device status is also available via equipment status screens and reports that can be printed. Many reports of device failure are taken over the phone from the public, partner agencies, maintenance staff, and other agency and contractor personnel. Failure calls are also received and relayed for devices (such as luminaires) that are not formally part of INFORM. Failures are logged manually in the main computer system, depending on the type of failure. Calls, pages, or faxes are sent to appropriate agency and maintenance contractor personnel.

Configuration Management

- There is no complete configuration management database, but the operations contractor does use an inventory program. Due to the extent and age of the system, the cost to develop a complete configuration database would likely be considerable.

Logistics

- New York State DOT and the operations contractor provided initial spares to the maintenance contractor, who then became responsible for needed spares. Spares are located at a central site. The maintenance contractor was afforded a period of months at the beginning of the maintenance contract during which to identify pre-existing problem conditions in the system.
- Because of the age of the original system, INFORM is encountering problems when attempting to obtain spares for some of the legacy equipment and experiencing long lead times and high costs due to custom fabrication. INFORM is investigating modifications to update and upgrade to more available devices.

Maintenance

- INFORM is experiencing challenges in achieving desired levels of quality and service from maintenance contractors. The maintenance contracts are awarded to the low bidder. Special needs, such as locating and retaining communications technicians and personnel with experience with the older generations of technology existing in the earlier portions of the system have been difficult to fulfill under existing contracting and labor conditions.

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Metropolitan Transportation Management Center

A Case Study

Michigan Intelligent Transportation Systems

Improving Safety and Air Quality While Reducing Stress for Motorists

October 1999

Foreword

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This case study reflects information gathered from interviews and observations at the downtown Detroit transportation management center. The authors appreciate the cooperation and support of the Michigan Department of Transportation and its partners in the development of this document.

Contents

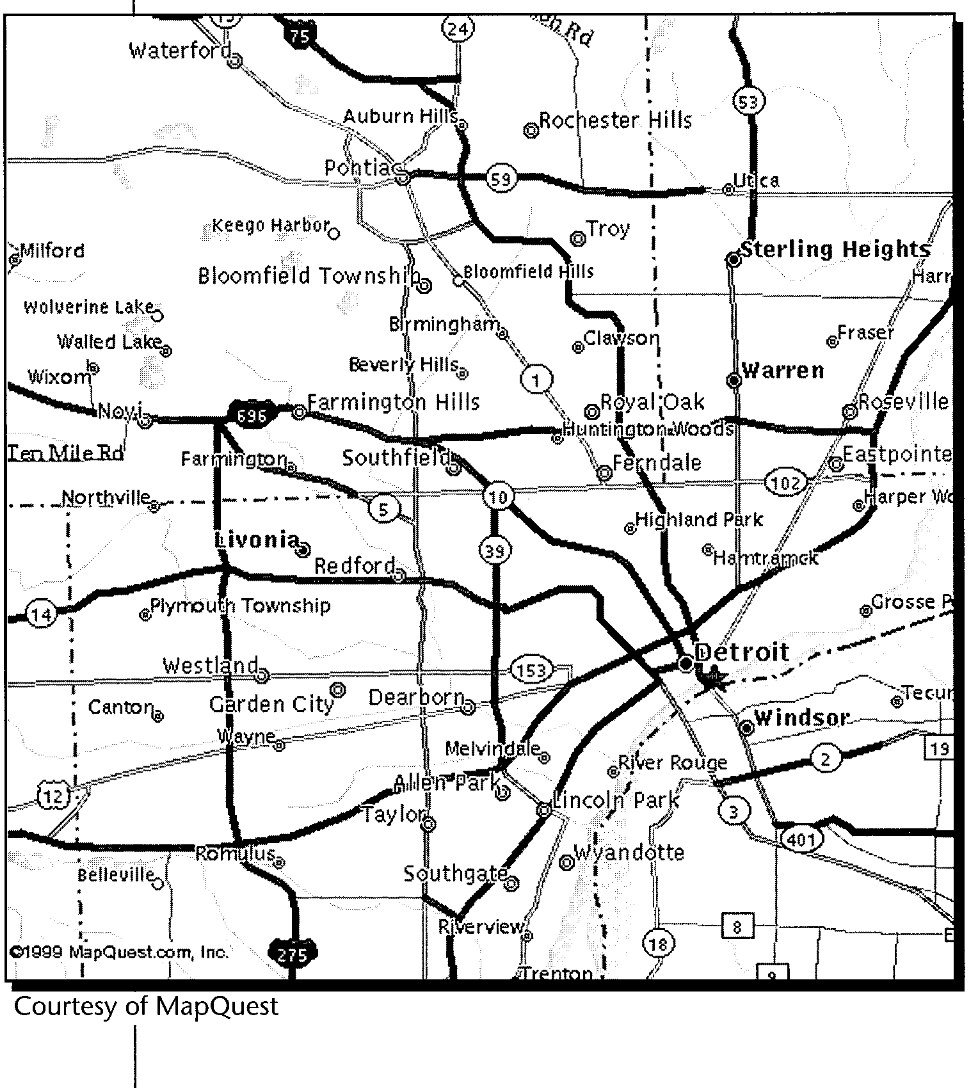
Background

The Michigan Intelligent Transportation System Transportation Management Center (MITSC) contains both an original system dating from 1981 covering 32.5 miles, and an expansion of the system to cover a total of 180 centerline miles of freeway that is still being constructed. The original system concept was prepared in 1969. On the basis of the performance of the original system, there was a desire within Michigan Department of Transportation for system expansion, but acquiring the necessary funding was a problem. Two years of Congestion Mitigation and Air Quality funding was eventually identified to fund the expansion.

A formal set of goals and objectives are being developed. Based on discussions to date, the primary system objectives are to:

- Improve safety and air quality
- Reduce stress for motorists.

The focus of activity in the MITSC is to make the traveler's trip less stressful by providing better information to the traveler. When a problem occurs, the MITSC helps Michigan State Patrol and others correct it quickly.



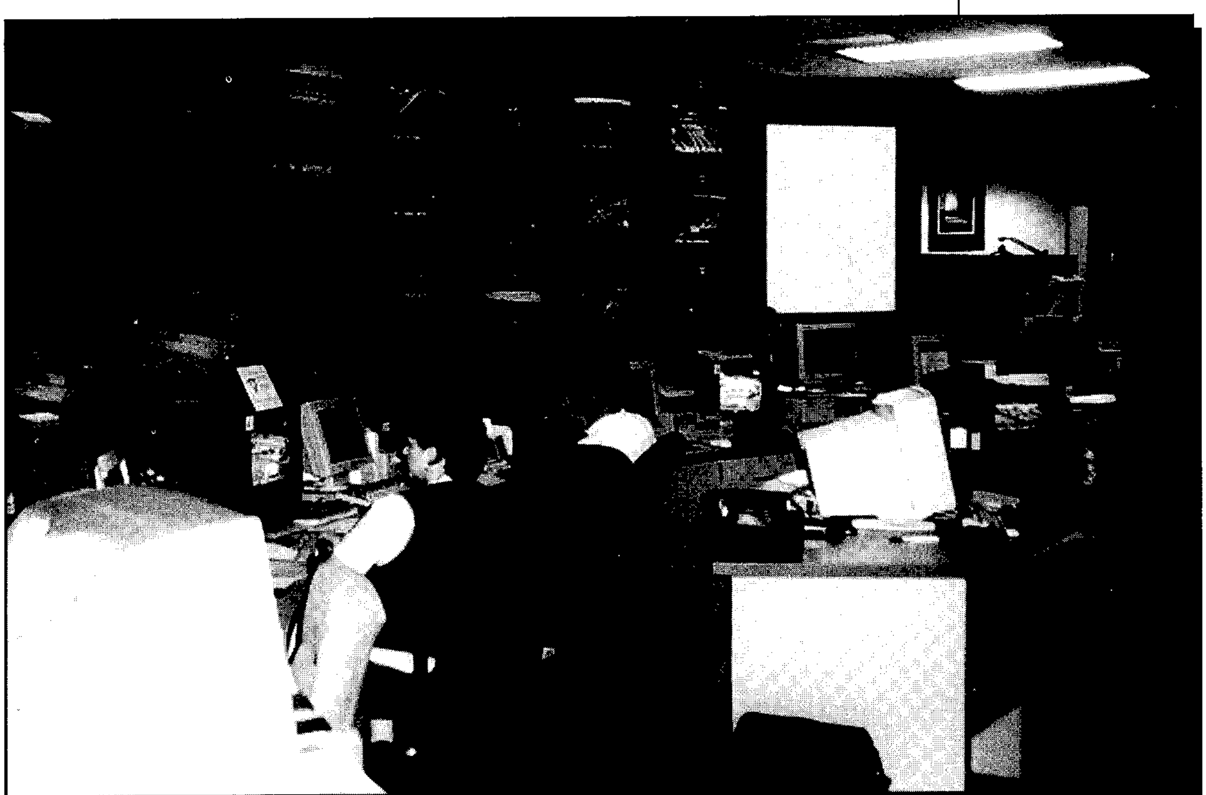
Courtesy of MapQuest

Design and Implementation

General system design parameters for Michigan's Intelligent Transportation System Transportation Management Center are the following:

- The older portion of the system includes ramp meters, detectors, and closed-circuit television with communications via coaxial cable. The portion being implemented includes the same components and Highway Advisory Radio, communicating via microwave and spread spectrum to an OC-48 fiber optic network.
- The control center is above the Greyhound bus garage in downtown Detroit with close access to the freeway. The control room is roughly 30 feet by 80 feet. The front of the room contains two dozen 25-inch color video monitors and an 8-foot by 9-foot video wall. Front to back, the room contains a row of four operator positions, a supervisor console, and then two rows of cubicles for Michigan State Patrol dispatch and other services. The rear of the room provides closed offices for the Michigan State Patrol.

The Detroit TMC developed special procedures to smooth traffic flow to and from major parking sites for its large downtown special events venues.



Design and Implementation

Method of Implementation

- The new system is being implemented through a firm fixed-price design/build/warranty contract. The contractor was selected based on best perceived value. The original system was implemented and has been expanded through conventional consultant design and low-bid construction contracts.

Testing

- The operational objective is for 95 percent of the equipment to be up 95 percent of the time, with no entire subsystem ever less than 95 percent reliable.
- Subsystem level acceptance is under way. Test plans were developed as part of the contract. Most testing is being performed by contractor personnel and witnessed by Michigan Department of Transportation staff.
- The operational readiness testing approach is being discussed. The system is available for use in a partially functional condition at the request of the Michigan Department of Transportation.

Training

- The contractor will provide training and operator and system documentation. Staff are being trained as new subsystems come online. New system staff are provided "hands-on" training by the Assistant Operations Manager.
- Once training materials are accepted, their upkeep becomes Michigan Department of Transportation's responsibility.

Documentation

- Operations procedures documentation will be prepared by Michigan Department of Transportation using word processing, computer aided design, and charting software. The computer aided software engineering tools the contractor used to develop the system software provide additional software documentation. An index-driven online help function is available.
- The implementation contractor is providing "as-builts" on CD-ROM.
- The contractor prepared detailed requirements documentation in response to the Request For Proposals, which had been prepared internally by Michigan Department of Transportation (MDOT) project staff.

Michigan DOT greatly enhanced coordination in incident management by co-staffing the TMC with Michigan State Patrol.

Operations

Workload and Performance

- There are two shifts, operated by three temporary personnel per shift. Shift break is at noon, with roughly a 30-minute overlap. Michigan State Patrol works 24 hours a day, 7 days a week with different shift breaks.
- System operation is being privatized; the privatization contractor is studying system operation.
- Typically six to twelve incidents that require active management occur daily. The system is also used to provide information regarding recurring congestion, including congestion related to the road construction in the area.
- Operator actions are logged manually. The new system will provide automatic logging of most activity.
- Operations staff work extensively with MDOT Construction and MDOT Maintenance in identifying faults and repairing field equipment. They also monitor radio traffic to maintenance staff and field engineers, and answer the MITSC's switchboard number.

Coordination

- Verbal coordination works effectively between Michigan State Patrol dispatch and MDOT operators. All personnel can view the front wall monitors and the large screen display. Michigan State Patrol has a Michigan Intelligent Transportation System workstation and video monitors and will have video control. The MDOT assistant TMC manager is stationed in the control room roughly 50 percent of the time.
- Coordination by telephone occurs with the Oakland County Roads Commission, whose FAST-TRAC traffic signal system can send its signal situation to MITSC. Oakland County Roads Commission can view and control MDOT's closed-circuit television cameras.
- Communication with the privately sponsored Courtesy Patrol is via cellular telephone.
- MDOT Construction faxes work zones and road closures to MITSC, where they are manually entered into the computer.
- There is no direct linkage between the MITSC control center and the local transit provider, SMART, although a significant and increasing amount of data from MITSC is available to SMART via the Internet.

Conflict Resolution

- The system database presents a unique recommended solution to each incident, based on incident location and type. Variable message sign and highway advisory radio messages can be edited manually. The TMC deputy manager and manager are located on site.

Nonstandard Operations

- Traffic management plans for special events are developed by ad hoc teams. MDOT coordinates with major parking facilities during special events.
- An emergency operation planning process will be implemented once the new system is accepted.

Maintenance

Fault Detection and Correction

- The new system indicates equipment malfunction through changes in icon color of the device on the system map. Not all devices are monitored constantly due to limitations on total communication bandwidth.
- Failures noted in use or reported by the system are logged manually, and calls placed to MDOT Maintenance, internal MITSC staff, or to the contractor.

Configuration Management

- The contractor currently maintains control for configuration management of the computer hardware and software. No formal MDOT configuration management program is in place for the total system.

Logistics

- MDOT Maintenance is identifying tools and spares that will be required outside of the warranty. Some purchases will be difficult due to limitations on sole-source acquisition. Acquisition of spares for the older system is a problem as many parts and tools are no longer available. MDOT is considering the upgrade or replacement of these devices.

Maintenance

- Maintenance is provided by two personnel from the MDOT district office. Discussions are under way regarding contracting for full system maintenance. Maintenance of the older system has become problematic due to loss of expertise in its technologies.
- The contractor is presently supporting control room equipment under a 2-year warranty that was included with the design/build/warranty contract.

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A Case Study

Milwaukee MONITOR

Addressing Congestion While Improving Safety and Air Quality

October 1999

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Christine M. Johnson
Program Manager, Operations
Director, ITS Joint Program Office
Federal Highway Administration

Edward L. Thomas
Associate Administrator for
Research, Demonstration and
Innovation
Federal Transit Administration

Preface

The following case study provides a snapshot of metro Milwaukee's MONITOR transportation management center. It follows the outline provided in the companion document, *Metropolitan Transportation Management Center Concepts of Operation — A Cross Cutting Study,* which describes operations and management successful practices and lessons learned from eight transportation management centers in the United States and Canada.

This case study reflects information gathered from interviews and observations at the MONITOR transportation management center. The authors appreciate the cooperation and support of the Wisconsin Department of Transportation and its partners in the development of this document.

Contents

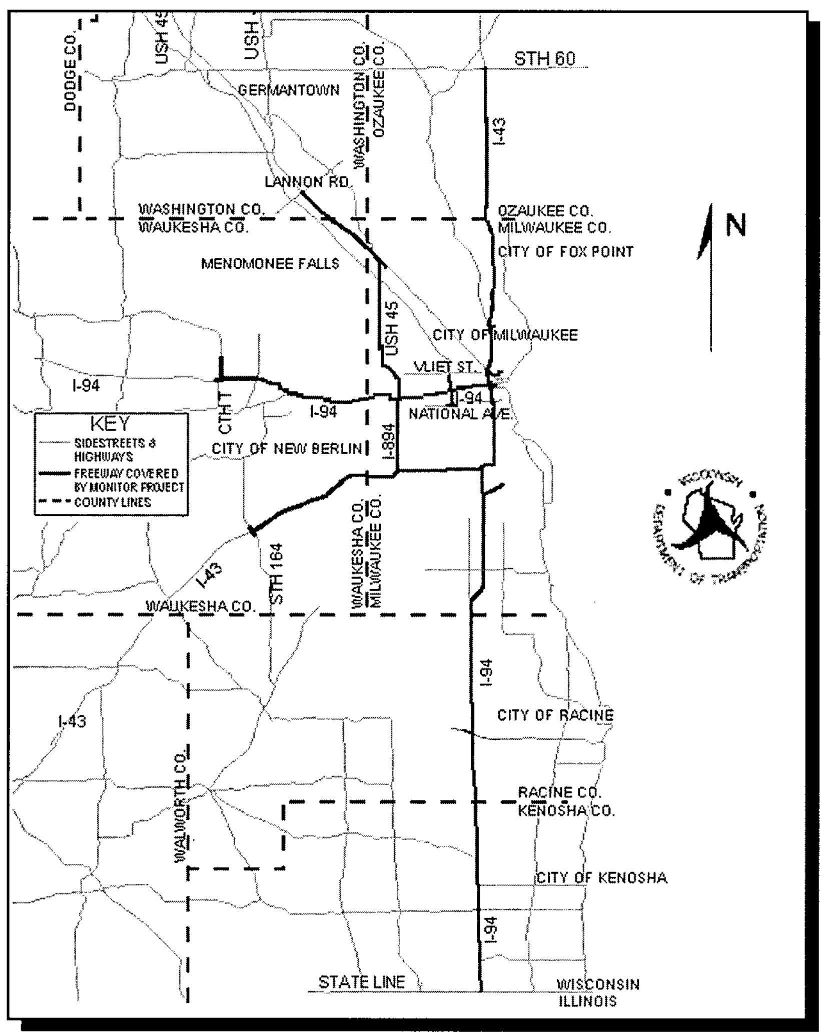
Background

MONITOR is the freeway traffic management system for metropolitan Milwaukee and continues to expand, covering an area beyond Milwaukee. The area freeways were planned in 1961, but the network was never completed. Although the road network provides potential diversion routes, there is no outer belt freeway, so commercial vehicle traffic travels through town. The regional planning commission recommended traffic management as early as 1978 due to congestion problems on, and incident vulnerability of, the existing freeway system. The initial major MONITOR deployment was to support traffic during rehabilitation of I-94, the East-West freeway.

The primary objectives of MONITOR are to:

- Address congestion
- Improve safety and air quality.

Causes of congestion are evenly split between recurring and incident-related traffic, including special events and construction. Nonrecurring congestion is expected to grow by 70 percent. In the metropolitan area I-94 experiences more than 100 crashes per mile per year, and much of the remainder of the freeway network has 50 to 100 crashes per mile per year.



Design and Implementation

General system design parameters for the MONITOR are:

- MONITOR uses loop pairs in every lane at 1/3–1/2 mile average intervals on the mainlanes and single loops on ramps. It also uses closed-circuit television at 1-mile increments, traffic responsive ramp metering with high-occupancy vehicle priority, freeway and arterial variable message signs, and highway advisory radio.
- The TMC occupies 6,500 square feet (increasing soon to 10,000 square feet) on the 12th floor of a downtown office building with indirect access to the freeway system. It contains a single row of consoles with three operator positions and four video monitors. The front of the control room includes four 20-inch video monitors and a 60-inch rear projection unit. (The picture below shows MONITOR's previous set up that has since been upgraded.) The facility also houses WisDOT MONITOR design, inspection, and maintenance personnel.
- The TMC is a leased facility. Many of the physical plant improvements have been performed to WisDOT specifications by the leaseholder.

MONITOR employs students from two nearby Universities—this provides valuable practical experience while MONITOR benefits from inexpensive and flexible labor resources.

Design and Implementation

Method of Implementation

- WisDOT employed consultants to design the field systems, which were then procured under conventional low-bid construction contracts. The computer system was designed, developed, and implemented by a consultant, based on another system that the consultant had completed. WisDOT is now investigating the replacement of its computer system, using separate design, oversight, and development consultants. WisDOT personnel are involved extensively in all design and deployment efforts for system expansion and upgrading.

Testing

- No major system upgrades have been performed, although the server and workstation operating systems have been updated. Archived data are available for testing.
- A plan for operations readiness testing of the suggested replacement system is being considered.
- No system test environment is maintained. Instead, testing is performed outside of core operations hours. System changes that successfully complete the testing period are then added to the system.
- Testing can be performed using either archived data or a "test data feed" provided by the original development contractor.

Training

- WisDOT has developed guidelines and procedures for system operation and other operations training material. A training manual has been developed for the on site law enforcement representative. New staff receive about 2 weeks of initial training. Training materials are kept current by temporary student staff. There are also classes on system administration and variable message sign control.
- Training for maintenance personnel is procured through commercially available courses and from vendors.

Documentation

- The initial design consultant/system developer provided extensive system and equipment documentation and initial training material for the computer system and control room equipment. Documentation on field equipment has been procured as part of the relevant construction contracts.
- Relevant documents include system "as-builts," a system design report, a system administration manual, system operations and reference manuals, and a changeable message signs guide.
- Documentation is maintained by WisDOT. Student labor has also been applied successfully to updating operations and system documentation.
- The system does not provide a Help function.

Workload and Performance

- The system is operated in two shifts, incorporating the a.m. and p.m. peaks. Each shift includes a permanent operator and at least one student operator. An additional student operator is on duty during mid-day off-peak periods with permanent operators available to assist. System startup is accomplished each morning by maintenance staff that verify operational status of the equipment. The system will not allow an operator to log out if the operator has devices active or an incident under management; a shift-transfer function is available.
- A dedicated liaison (captain rank) with the county sheriff is stationed at the TMC and paid for by WisDOT. This individual supports control room operations. Control room staff are provided a sheriff's department radio tuned to the traffic frequency, and also have a scanner monitoring highway maintenance and other relevant agencies.
- A majority of incidents are detected by monitoring congestion levels on the area map, through calls from the sheriff (who receives 911 calls), and calls from the enhanced service patrol. Variable message sign messages are input manually and monitored by a "reminder" system function. Camera control is through a keypad/joystick separate from the workstations.
- The system monitors 63 centerline miles of freeway, with 25 additional miles due to come online in 1999 and 15 more in 2000 for a total target of 130 centerline miles, including 130 ramp meters, 75 closed-circuit cameras, and 30 variable message signs.

MONITOR benefited from a variety of perspectives by locating ITS planning, design, construction, and operations and maintenance personnel in the TMC.

Coordination

- Coordination with emergency services and the service patrol is through the on site sheriff's department liaison.
- Transit integration with traffic management has been identified as a need for the greater Milwaukee area. Discussions to date center on sharing of traffic information and video, and on providing real time transit information from the Milwaukee County Transit automatic vehicle location system to patrons online. Funding has been identified, but further action is awaiting completion of Y2K activity.

Conflict Resolution

- Because of the proximity of the key personnel, no special arrangements are necessary for conflict resolution. The TMC manager is available on-site.

Nonstandard Operations

- Based on recent experience with area flooding, emergency situation planning is being considered.
- WisDOT staff gather information on all construction and lane closures and fax this to a wide variety of users weekly. Real-time updates are provided by radio or phone.

Maintenance

Fault Detection and Correction

- The system indicates faults of some devices by changing the device icon color on the system map. A maintenance database into which problems are entered and resolution tracked has been developed by WisDOT and is used extensively in tracking equipment status and reliability. Faults are also reported by WisDOT personnel and law enforcement.

Configuration Management

- The system has received many minor fixes and a few internally added functions, but no major system upgrades. No configuration management tool or baseline was provided by the system design or implementation contractors.

Logistics

- Software development and system maintenance tools have been procured directly by WisDOT. WisDOT is considering a software maintenance contract for its next generation system. WisDOT procures spares required for maintenance activity through purchase orders.

Maintenance

- Two years of maintenance was bid into the initial installation contract. At its expiration, field equipment maintenance was separated into variable message signs and "all others," and bid as purchase order type contracts. Communications maintenance is provided by the network provider. WisDOT provides spares for maintenance. The maintenance contractor is responsible for coordination with active warranties.
- WisDOT staff maintain control room equipment. A program of continuing upgrade and replacement of computer equipment is in place.
- WisDOT is considering an increase in maintenance contractor staffing to improve preventive maintenance coverage.

MONITOR serves as a source for information on and authorization of road closures throughout the region.

For further information, contact:

Federal Highway Administration Resource Centers

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10 S. Howard Street, Suite 4000 – HRA-EA
Baltimore, MD 21201
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Notes

Metropolitan Transportation Management Center

A Case Study

Georgia NaviGAtor

Accurate and Timely Information to Navigate Georgia Roads

October 1999

Foreword

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Federal Transit Administration

NOTICE

Preface

The following case study provides a snapshot of Atlanta's NaviGAtor transportation management center. It follows the outline provided in the companion document, *Metropolitan Transportation Management Center Concepts of Operation — A Cross Cutting Study,* which describes operations and management successful practices and lessons learned from eight transportation management centers in the United States and Canada.

This case study reflects information gathered from interviews and observations at the NaviGAtor transportation management center. The authors appreciate the cooperation and support of the Georgia Department of Transportation and its partners in the development of this document.

Contents

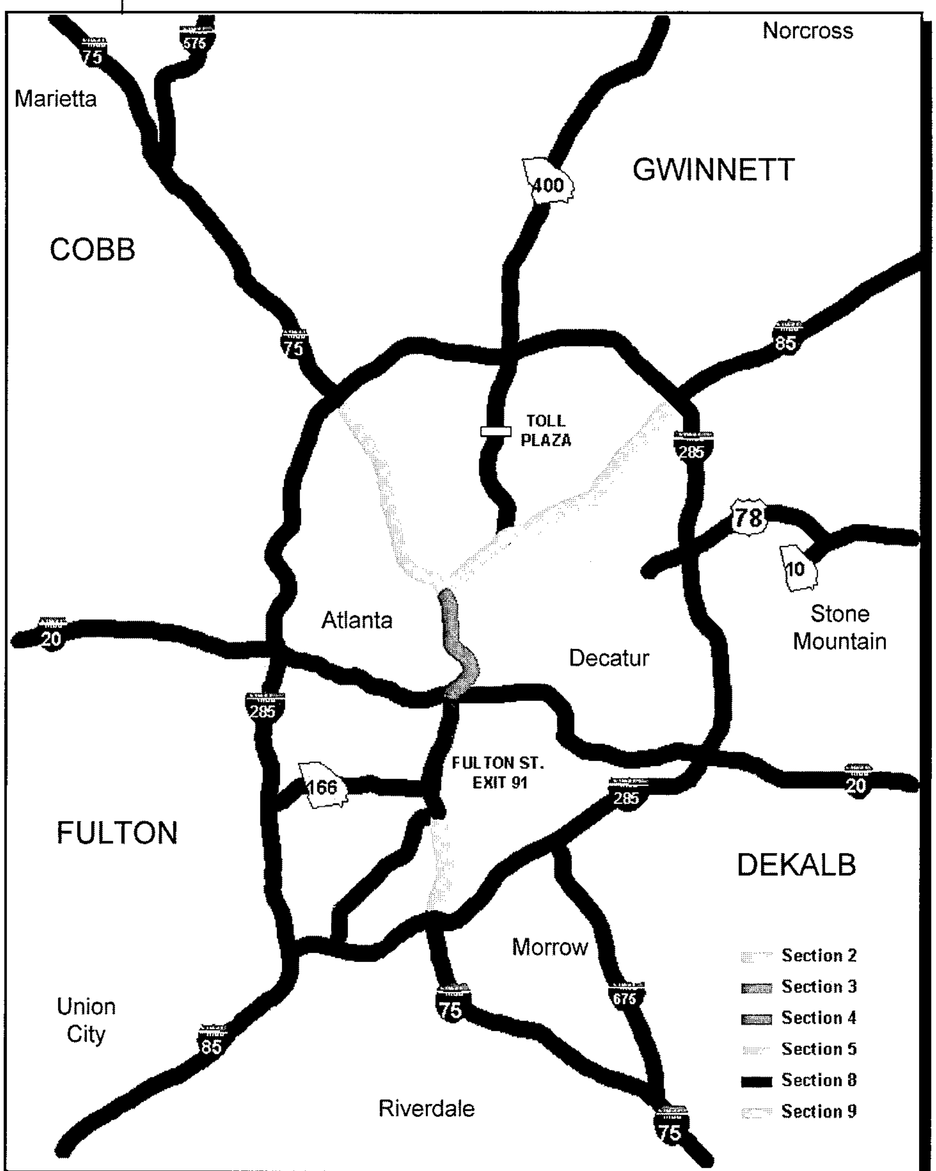
Background

The system was originally conceived to address incident management, congestion management, and motorist assistance needs for the 1996 Olympic Games in Atlanta.

The primary objectives for the transportation management center is to obtain and disseminate accurate and timely information for navigating Georgia roads.

In support of this mission, the system performs incident management and provides motorist assistance.

- The NaviGAtor TMC architecture includes the statewide control center working cooperatively with control centers for each city, county, or transit agency in the Atlanta metropolitan area, along with additional control centers elsewhere in the State.

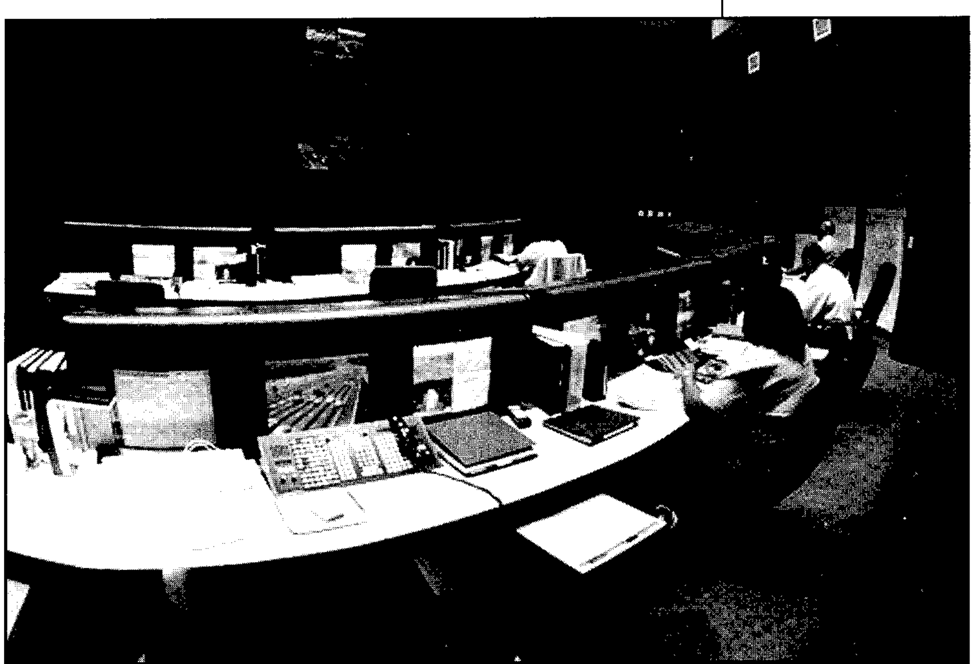


Design and Implementation

General system design parameters for NaviGAtor include the following:

- The TMC is a 73,498 square-foot facility with four floors and a basement. The fourth floor houses Georgia Department of Transportation (GDOT) motor carrier and high occupancy vehicle enforcement. The TMC is in a State government complex in eastern Atlanta with access to I-20 via two arterials. The facility opened in 1996.
- The TMC has access to the fiber optic network, the public phone system, three radio systems (Highway Emergency Response Operators, high band, low band), and an aerial surveillance microwave link. The TMC is supported by an uninterruptable power supply and diesel generator, including dual power feeds. The building also offers an 11,000 square-foot garage, showers/locker room, and overnight facilities. Security includes swipe cards on all doors and elevators, a guard at the entrance, and security cameras outside. It cost $13 million to build the TMC, not including the Advanced Traffic Management System software and integration.
- The control room features two rows of consoles with three positions in the first row and five positions in second. The operations manager is in an office located behind the consoles. The control room measures 36 square feet, shaped roughly like a baseball diamond. Each operator position has a single monitor computer workstation, two 19-inch video monitors, and an integrated radio/telephone console. The front of the room has 9, 120-inch diagonal rear projection units that each display a matrix of screens 3 high and 3 wide. Six of the 120-inch units are shown below. The computer system controls all functions, including video.

On-site Georgia DOT public affairs staff contribute significantly to NaviGAtor image and outreach programs.



Design and Implementation

The use of training materials and hypertext in Help functions greatly improves the ease and speed of access to procedural information.

- The Advance Traveler Information System contains 48 miles of closed-circuit television, 63 miles of conduit, detectors of several types, variable message signs, and ramp metering on a small section of the metropolitan interstate network.
- The TMC provides text data and four cameras to the regional cable TV system. There are several cameras to which local media can link with communication equipment already installed in the TMC. A broadcast booth is provided for the media, with a view into the control room.

Method of Implementation

- Georgia DOT hired a system manager consultant to design the system, develop and provide the computer system and system documentation, and conduct testing, training, and systems integration. The system manager was chosen using a qualification-based selection and was awarded a cost plus fixed fee contract. Implementation was accomplished through multiple, low-bid, fixed price contracts with Georgia DOT inspection.

Testing

- System testing was performed by the system manager. Georgia DOT staff conducted testing, as did device installation contractors and "hookup" contractors who returned the connection to the TMC.

Training

- Georgia DOT has established a training group that prepared the operations procedures. New operators receive 2 weeks of training on console operation and use of the Advance Traveler Information System software. Operators are then trained on duties, procedures, and response planning (3 to 4 days per item). Trainees tour the project area and ride with Highway Emergency Response Operators. Georgia DOT estimates 6 months for an operator to become efficient.

Documentation

- Core documents provided to operators include standard operating procedures, incident management handbook, equipment manual, location guide, Advanced Traffic Management System users guide, signal listing, TMC equipment guide, and directory (points of contact). There is also an operations supervisors guide. Operations documents have been developed by TMC staff.
- The Georgia DOT-developed system Help function is available by subsystem or alphabetic search/index with hypertext links.

Workload and Performance

- The TMC is staffed 24 hours a day, 7 days a week in three shifts with four operators on prime shift, along with district/maintenance, Highway Emergency Response Operators, and two operators with a supervisor or manager on weekends and nights. Operator shifts overlap by 30 minutes. At shift change, supervisors update oncoming operators.
- System algorithms did not provide satisfactory automatic incident detection, so incidents are detected by calls from motorists, Highway Emergency Response Operators, and police, observed on video monitors or on the traffic speed maps.
- The operators are assigned duties focused on incident entry, notification, maintenance interface, or construction functions. The system recommends a response plan based on incident type, impact, and location. The operators also use a Web-based pager function. Operators also answer *DOT calls.
- Georgia DOT estimates five incidents per hour daily, with higher numbers during peak periods. A significantly greater number of motorists are assisted by Highway Emergency Response Operators.

Coordination

- All components of the Intelligent Transportation Systems program report to the Georgia DOT operations directorate. Planning, design, operations, and maintenance are housed in the TMC.
- Operators communicate verbally across consoles with one another, by radio with Highway Emergency Response Operators, and by phone with the fire department, emergency medical services, and law enforcement. The Highway Emergency Response Operator calls wrecker services contracted with local jurisdictions.
- The TMC shares information electronically with the traffic control centers at the city of Atlanta, the five area counties, Savannah, and Athens. Design is under way for traffic control centers for Macon and Augusta. Traffic control centers can enter reported incidents within the computer system. Both the traffic control centers and MARTA have video and computer access. The TMC also receives faxes on construction activity from local agencies.
- Transit is a vigorous partner with traffic management in Atlanta. MARTA, the regional transit authority, houses one of the NaviGAtor Transportation Control Centers in its bus control room, providing MARTA with full access to all traffic information contained within the NaviGAtor computer system. MARTA is also able to enter or modify incident, congestion, or other information into the center, based on reports received from its vehicle operators, with the same capability as if it were in the TMC.

Operations

Conflict Resolution

- Decision-making authority passes from the operator to the shift supervisor to the operations manager to the TMC manager. More senior levels of Intelligent Transportation Systems and Georgia DOT operations management are also on site. Key decision makers are available by telephone, cellular phone, and pager.

Nonstandard Operations

- A procedure for operations responsibilities during emergencies has been prepared. The Georgia Emergency Management Agency is located in an adjacent building.
- Jurisdictions notify Georgia DOT of road closures for special events. The TMC prepares plans for dealing with sporting event traffic congestion.

Fault Detection and Correction

- Operators perform equipment checks weekly, supplementing the automatic fault detection, reporting, and logging performed by the system. The system also detects and reports over-temperature conditions in equipment cabinets. The system map indicates failed equipment or communications by a change in icon color on the system map. A screen posts a listing of devices noted as failed by the system. Many failures are noted when operators attempt to use a device. The Web site system of video captures notes and reports when it is unable to acquire an image.

Configuration Management

- A configuration manager, supported by a configuration management engineer, has been added to the staff. Georgia DOT is documenting the system's configuration after the fact. Configuration management on software is provided by Georgia DOT information systems. The new system manager has been tasked with auditing the software and creating a configuration management baseline. The configuration management database will include not only the statewide TMC, but also the city, county, transit, and remote TMCs.
- Creation of the configuration management database is complicated given the numbers of contracts and contractors who were included in the system implementation.

Logistics

- Initial spares, tools, and test equipment were procured through the installation contracts. Georgia DOT can directly purchase these supplies below a certain value, but above that value Georgia DOT must obtain multiple bids. Installation contractors provided equipment support for 2 years after acceptance. For system expansions, Georgia DOT specified that warranties begin at system acceptance. Warranties are managed by the system support contractor.

Maintenance

- Georgia DOT emphasized the importance of having an internal information technology team. In addition to its own resources, Georgia DOT will use the system manager to continue debugging, expanding, and enhancing the computer system. Georgia DOT also retains specialist consultants in areas such as the Geographic Information System.
- Georgia DOT is increasing maintenance contracting. It recently initiated a contract for preventive maintenance of variable message signs. This contractor does preventive maintenance (bulbs and filters) every 6 months, according to a Georgia DOT-developed plan. The contractor also is required to report likely problem areas.

NaviGAtor implementation was the first significant demonstration of the system manager procurement approach in ITS.

For further information, contact:

Federal Highway Administration Resource Centers

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10 S. Howard Street, Suite 4000 – HRA-EA
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Metropolitan Transportation Management Center

A Case Study

Arizona TrailMaster

Providing a Safe and Efficient Travel Environment for Users

October 1999

Foreword

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Preface

The following case study provides a snapshot of Arizona's TrailMaster statewide transportation management center. It follows the outline provided in the companion document, *Metropolitan Transportation Management Center Concepts of Operation — A Cross Cutting Study,* which describes operations and management successful practices and lessons learned from eight transportation management centers in the United States and Canada.

This case study reflects information gathered from interviews and observations at the TrailMaster transportation management center. The authors appreciate the cooperation and support of the Arizona Department of Transportation and its partners in the development of this document.

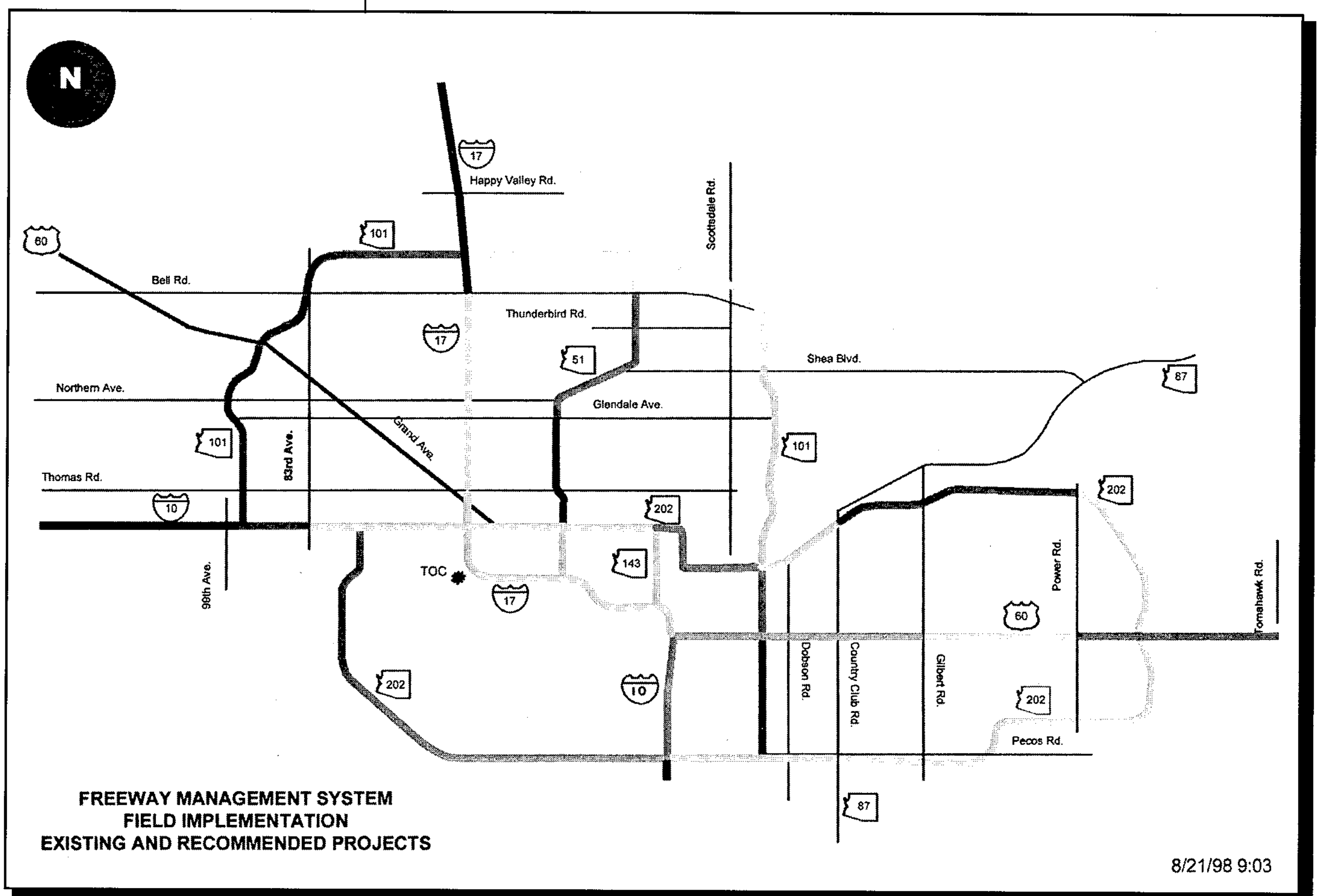
Contents

Background

In 1986, the Arizona Department of Transportation (ADOT) completed a study along I-17 and I-10. Based on the results of this study ADOT recommended that a freeway management system be implemented in metropolitan Phoenix. Consequently TrailMaster was developed to accomplish the following:

- Support optimum use of the freeway system
- Provide a safe and efficient environment for users
- Allow for more efficient use of ADOT resources.

Additional documents about the purpose and approach of TrailMaster include a feasibility study, a functional design document, and a statewide deployment plan.



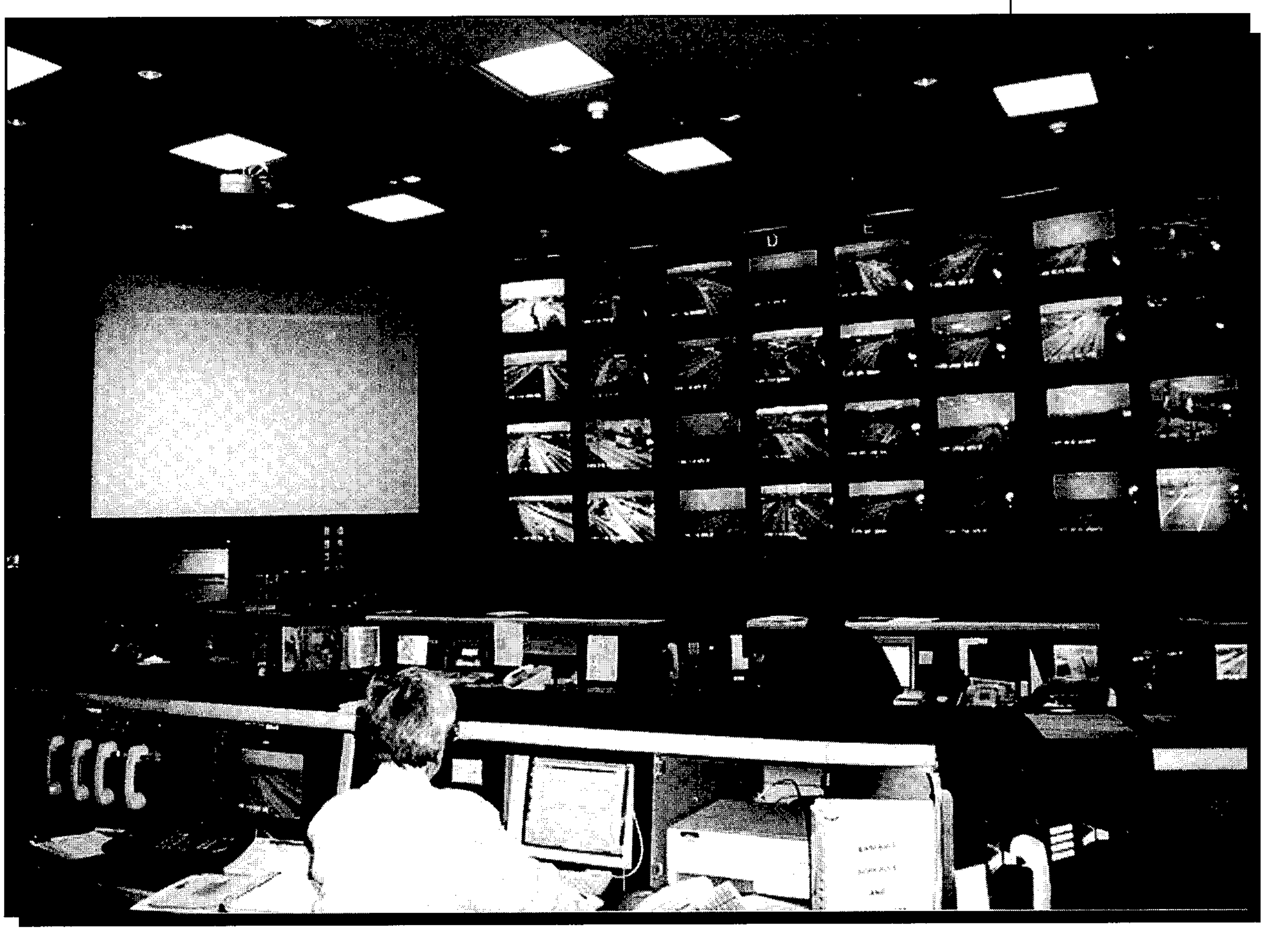
FREEWAY MANAGEMENT SYSTEM
FIELD IMPLEMENTATION
EXISTING AND RECOMMENDED PROJECTS

Design and Implementation

The general system design parameters for TrailMaster are the following:

- The TrailMaster transportation management center (TMC) is an 18,000 square-foot, two-level facility located in central Phoenix. Cost to build the facility was $2.8 million, not including the puchase of control room equipment. Expansion of the TMC's role to include statewide traffic management requires more space than the current control room provides, so remodeling is planned.
- The control room has five operator positions arranged in two rows, one tunnel operations position, one radio position, a station for local media, and a separate supervisor's office. Each console position has one or two computer workstations and a 13-inch video monitor. Thirty-two 25-inch video monitors, most of which scroll between camera images, are located in the front of the control room. At the side of the room, a 9-foot front projection system displays the system map; the TMC has plans to purchase a second unit to display a statewide map.
- TrailMaster will support 254 centerline miles of Phoenix metropolitan area freeway and eventually a significantly larger number of miles of rural interstate. Closed-circuit television and variable message signs are located at 1-mile intervals, detector pairs are positioned in every lane at 1/3 mile intervals in the metropolitan area. Communications is through a hybrid fiber optic network and dialup connection.

ADOT has reduced the deployment cost and helped standardize equipment by using multi-year purchase agreements.



Design and Implementation

Operations and Maintenance staff participate actively in TrailMaster's future by planning deployment projects and system improvements.

- Incidents are detected primarily by monitoring video images and through calls from cellular 911 and partner agencies. Incidents are entered manually in the computer system. Messages for individual variable message signs are selected by location and type of incident, and edited as appropriate. Closed-circuit television control is maintained through control panels separate from the workstations.
- Traveler information is provided via an on-site broadcaster, Web site, video feeds to other media, the AZTech metropolitan model deployment initiative kiosks, computerized telephone, and bulletin board systems.

Method of Implementation

- A local consultant was retained to design the TMC, which was procured through a conventional construction contract.
- The consultant prepared the Advanced Traffic Management System functional design and designed much of the field equipment, which was procured through low-bid contracts.
- This consultant also developed the computer system, costing $12 million for design and development.

Testing

- The system design consultant provided a test plan that included input from operations, project management, and consultant staff.

Training

- The system design consultant provided initial operations training. Field equipment training was provided via the first installation contract. Software development consultants provide informal hands-on training for new personnel.
- New hire training is primarily on the job, supervised by senior operators and the operations supervisor.

Documentation

- Documentation includes a systems users manual, plans and specifications, a functional decomposition, construction equipment submittals, "before" and "after" evaluation subsystem design documents, a two-volume software design, and an operations plan, which is being updated.
- The system does not provide a Help function.
- ADOT has staffed a main shift traffic analyst to perform analyses of incident and flow data and to provide system data to outside organizations.

Workload and Perfomance

- The control center is staffed 24 hours a day, seven days a week in three shifts, using staggered shifts with extended overlaps.
- At shift-change, incidents can be transferred between operators within the system.
- Operators review active incidents and equipment status problems and conduct other activities such as coordinating with law enforcement and maintenance, answering calls, and controlling facility access.
- Logs indicate 40 to 60 incidents occur daily within the Phoenix metropolitan area. (The system is not yet in statewide operation.)

Coordination

Several agencies coordinate TrailMaster operations:

- Arizona Department of Public Safety dispatchers will be stationed in the control room. At present, contact with the Department of Public Safety is by telephone.
- The ADOT district office maintains TrailMaster. Operators have radio access to ADOT maintenance offices and vehicles throughout the State and can perform computerized alphanumeric paging.
- The Highway Closure Reporting System, an inter/intra-agency system that receives input from all districts, is reported as one of the TMC's most successful tools for communicating planned road closures. The Highway Closure Reporting System also provides access to forecast information from the National Weather Service, and it will contain input from the State's road weather information system. Highway Closure Reporting System output is accessible via the Internet.
- Current information sharing between the TrailMaster TMC and the regional transit authority is through an electronic link to the AZTech model deployment initiative server. This provides transit with direct access to extensive raw traffic data on both freeways and arterials, and to the real time incident and construction data published by TrailMaster. AZTech transit schedules are available online to patrons, generating over 3000 hits per month. Future improvements include plans for video on arterials which will be shared with transit.

Conflict Resolution

- Decision making is supported by the operations supervisor and TMC manager, both of whom are available by pager.

Nonstandard Operations

- Rural interstate incidents which require coordination of widely dispersed resources, can take longer to detect and clear than metropolitan incidents and be more severe due to the higher speeds in those areas. Queues can grow to many miles, creating conditions hazardous to motorists and vehicles, particularly due to the region's intense heat, dry climate, and the isolation of its vast rural areas.

Maintenance

Data that TrailMaster archives onto CD-ROM provide an excellent source of information for analysis and long-range planning.

ADOT developed a comprehensive maintenance program for TrailMaster.

- Maintenance resources are supplemented by warranties on field equipment.
- ADOT personnel maintain the computer system and manage the local and wide area communications networks.
- ADOT implemented an extensive preventive maintenance program and has contracted filter replacement and fluid replenishment on field devices.
- Specialized maintenance techniques were developed for common problems such as gunshot damage.
- Maintenance personnel are developing a maintenance training program for personnel maintaining the intelligent transportation systems field equipment.

Fault Detection and Correction

- The system polls variable message signs for status every 20 seconds and notes loss of data from detectors. These are indicated by a change in icon color on the system map. Closed-circuit television failure is noted from visual observation of scrolling images. (Ramp meters are presently on local control and will be on central control in the long term.)

Configuration Management

- Configuration management of the system software is performed using a computer-aided software engineering tool.
- A database of devices, locations, and communications configuration has been developed.
- ADOT is assigning an employee to conduct formal configuration management.

Cost/Benefit Analysis

- A consultant has recently completed a study of the cost of maintenance of TrailMaster for the next 15 years.

Logistics

- Initial spares, tools, and test equipment are procured through the construction contracts.
- Additional spares are procured through purchase agreements.
- Spares are stocked centrally but will be distributed geographically as the system expands.

Maintenance

- An online multi-user maintenance management system is being developed that would allow operators to enter problems and view repair plans and status.

For further information, contact:

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Notes